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HISTORICAL RADIOLOGICAL ASSESSMENT

NAVAL SUBMARINE BASE BANGOR

Volume II

GENERAL RADIOACTIVE MATERIAL

1973 - 1996

RADIOLOGICAL CONTROL OFFICE
PUGET SOUND NAVAL SHIPYARD
BREMERTON, WASHINGTON 98314-5001

May 1998

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1.0 Executive Summary

1.1 Purpose

This Historical Radiological Assessment (HRA) was prepared by Puget Sound Naval Shipyard (PSNS) for Naval Submarine Base Bangor (Subase Bangor) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA). The purpose of this HRA is to catalog and present over 20 years of radiological environmental data within the framework of the CERCLA process and within the pathway scoring protocol of the revised Hazard Ranking System (HRS).

Volume II of this HRA addresses general radioactive material (G-RAM), including all non-Naval Nuclear Propulsion Program (non-NNPP) applications of radioactivity. These include Radiological Affairs Support Program (RASP) material and unregulated consumer products. Volume I addressed radioactivity associated with the NNPP. Different branches of the Navy are responsible for these categories of radioactivity, and different historical practices have applied.

1.2 Background

Requirements for the control of any G-RAM at Subase Bangor, even before passage of the 1954 Atomic Energy Act, were based on recommendations of the National Committee on Radiation Protection and Measurements (NCRP, founded in 1931, chartered by Congress and renamed in 1964 to the National Council on Radiation Protection and Measurements). The Navy's radiological safety regulations, as revised in 1951 by the Bureau of Medicine and Surgery, invoked applicable recommendations of the NCRP (published at that time as National Bureau of Standards Handbooks) for specified radioactive material hazards. Historical G-RAM practices are outlined in Section 4.4.3.

Non-licensed G-RAM has been used at Subase Bangor since at least the mid-1940's for various purposes. The earliest documented use of licensed G-RAM at Subase Bangor was for industrial radiography. Shipyard records include a documented survey of radioactive sources within the NDTIB (record used this abbreviation, believed to refer to non-destructive testing) building, POLARIS Missile Facility, Pacific (POMFPAC) at Naval Ammunition Depot (NAD) Bangor in 1965. Licensed G-RAM at Subase Bangor is described in Section 4.4.

In July 1973, before Trident Refit Facilities were constructed, a baseline study of the radiological environment of Subase Bangor and surrounding waters was conducted by PSNS. Radiological environmental monitoring by PSNS has continued through the present. Results are forwarded to the NNPP headquarters which, since 1967, has published an annual report with distribution to other federal agencies, states, Congress, and the public. Although conducted by the NNPP, this monitoring is additionally indicative of the presence or absence of G-RAM, and pertinent results of this monitoring are included in this volume.

Independent surveys of the harbor by the Environmental Protection Agency (EPA) and the State of Washington Department of Social and Health Services have also been conducted. These independent verifications have been consistent with Navy results.

1.3 Findings

Of all the radiological data collected by the Navy, the Environmental Protection Agency, and the State of Washington Department of Social and Health Services; no radioactivity attributable to G-RAM operations has been detected in the vicinity of Subase Bangor.

The absence of detectable radioactivity in the environment attributable to G-RAM indicates that the controls applied to G-RAM at Subase Bangor have historically been consistent with federal regulations and with national scientific committee recommendations.

1.4 Conclusions

This HRA concludes that: (a) operations involving G-RAM at Subase Bangor have had no adverse effect on the human population or the environment of the region; and (b) independent reviews by the EPA and the State of Washington Department of Social and Health Services are consistent with these conclusions. Puget Sound Naval Shipyard concludes that no additional characterization and no remedial actions are necessary as a result of G-RAM activities at Subase Bangor.

2.0 Introduction

2.1 Background

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 established a process whereby past private sector disposal sites were scored for environmental contamination, and remedial action initiated where warranted. Federal facilities were not included within CERCLA; however, under Executive Order 12316 of August 20, 1981, the President directed the Department of Defense (DOD) to conduct similar evaluations of their installations.

By the mid-1980's, most DOD facilities had been evaluated. These Initial Assessment Studies were conducted for Naval shipyards and operating bases where nuclear powered ships were maintained and berthed. The Subase Bangor Initial Assessment Study (IAS), Reference 1, was completed in 1983.

During 1986, DOD realigned its programs to be more consistent with those of the Environmental Protection Agency (EPA) in the private sector. Initial Assessment Studies paralleled the Preliminary Assessments and Site Inspections of CERCLA. Confirmation Studies paralleled the Remedial Investigation and Feasibility Studies of CERCLA.

The Superfund Amendments and Reauthorization Act (SARA) of 1986 required that federal agencies comply in the same manner and extent as private entities and allowed federal activities to be placed on the National Priorities List (NPL). Executive Order 12580 of January 23, 1987 gave additional jurisdiction to the EPA for federal facilities on the NPL.

SARA also directed the EPA to revise its Hazard Ranking System (HRS) used to score sites undergoing the CERCLA process. This was completed and the revised HRS was published in the Federal Register in December 1990.

The EPA scored Subase Bangor under the original Hazard Ranking System. Data collected during the 1983 IAS, Reference 1, was used in this scoring. Due to past chemical disposal and control practices, EPA proposed Subase Bangor for listing on the NPL on July 14, 1989. Subase Bangor was listed on the NPL on August 30, 1990. The 1983 IAS and the HRS scoring did not include consideration of any past releases of radioactivity associated with G-RAM since the emphasis during those efforts was on industrial and chemical pollutants.

2.2 Purpose

This Historical Radiological Assessment (HRA) was produced to provide a comprehensive review and assessment of the impact of radiological operations at Subase Bangor. This assessment is organized in a format similar to the standard Preliminary Assessment (PA) protocol used by the EPA within the CERCLA process. This format was chosen as a vehicle that is in common use and is easily understood.

Environmental radiological data collected for Subase Bangor are cataloged and presented in Section 6 within the pathway evaluation protocol of the PA. Additional environmental data collected by the EPA and their independent conclusions are included in the relevant sections of this volume.

Section 8 of this assessment addresses each pathway along with the salient data results contained in previous sections and evaluates estimates of impact to the public and to the environment from operations associated with G-RAM.

This assessment is historical in that the regulatory and policy changes that have occurred during the evolution of G-RAM work are described.

2.3 Methods

2.3.1 Counting Terminology

"Gross gamma" spectrometry systems used for counting environmental samples are currently calibrated to respond to gamma energies between 0.1 MeV and 2.1 MeV, and thus detect a combined total of all radionuclides with gamma energies between 0.1 and 2.1 MeV. (The gross gamma energy range for counting systems used in 1973 was between 0.1 and 2.0 MeV). Where activity in this range is above 1 pCi/g, detailed radionuclide analysis is generally performed to determine whether all the activity is due to natural or fallout-related radionuclides. For some analyses (e.g., modern environmental monitoring sediment, water, and biota samples), detailed radionuclide analysis is performed regardless of measured gamma levels.

Gross gamma is measured in the gamma energy range of interest (0.1-2.1 MeV) using the efficiency value of cobalt-60, since surveys are conducted by the NNPP and cobalt-60 is the limiting radionuclide of concern in that program. Natural background and G-RAM radionuclides generally have only one gamma per disintegration, of lower energy than cobalt-60's two gamma's (potassium-40 is an exception). Hence, actual background radioactivity and G-RAM radioactivity are likely higher than measured and reported by this procedure. Nevertheless, this is acceptable since background radioactivity is not of concern, and since gamma-emitting G-RAM radionuclides, if present, will cause a detectable increase in measured levels.

When detailed radionuclide analyses are performed, germanium detectors are used. Specific photopeaks are used to identify and quantify specific radionuclides.

2.3.2 The Investigatory Process

The pathways, targets, and potential release mechanisms described in this HRA were used to guide the process of selecting the information to be reviewed in preparing this assessment. During the course of the investigation, they were used to gauge the adequacy of the historical record of radiological work at Subase Bangor.

Information descriptive of Subase Bangor was in large measure taken from recent Navy Installation Restoration documents. Navy, PSNS, and Subase Bangor correspondence and history files were reviewed to ensure all potential source terms of radioactivity were identified. Navy, PSNS, and Subase Bangor historical records were reviewed to ensure that an accurate account is presented of past requirements and practices.

All available records related to release, monitoring, and waste disposal were reviewed to determine: where radiological work was performed; what the environmental impact of radiological operations has been; and the history of radioactive waste disposal. Records were reviewed to determine if any inadvertent releases of radioactivity to the environment were not immediately remediated. A more detailed discussion of the specific types of records reviewed, and the results of that review, are contained in Section 5.

2.3.3 Interviews

Interviews concerning non-NNPP radiological operations were conducted with long-term employees having a total of over 84 years of experience at Subase Bangor during preparation of Reference 1 (1983 IAS). Paragraph 6.1.4.1, Radiological Operations, General, of Reference 1 which discusses the interviews, concluded:

“Analysis and investigation indicate that all identified past and present applications and operations dealing with radioactive materials at Subase Bangor were or are being conducted in a safe manner in accordance with past and current directives and practices”

During preparation of Volume I of this HRA, Puget Sound Naval Shipyard interviewed about a dozen long-term and previous employees. Persons interviewed included the current Trident Refit Facility (TRF) RadCon Officer (1995 - 1996), his predecessor (1992 - 1994), and the first person assigned to the Radiological Controls Department at TRF (1979 - 1982). No cases of unreported environmental releases of radioactivity or unauthorized disposal of radioactive material were identified.

During preparation of Volume II of this HRA, Puget Sound Naval Shipyard interviewed the Bangor Radiation Safety Officers (TRF and SWFPAC), and the NAVSEA Radiation Safety Officer (See Section 4.1.6). All Radiation Safety Officers stated, to their knowledge, there have been no cases of unreported environmental releases of G-RAM radioactivity or unauthorized disposal of G-RAM radioactive material at Subase Bangor.

2.3.4 Units

Units used throughout this report include: pCi/g (picocurie per gram), kcpm (thousand counts per minute), mrem/hr (millirem per hour), mrem/qtr (millirem per quarter year), and μ R/hr (microrentgen per hour). A further explanation of a particular unit can be found in the glossary.

3.0 Site Description

3.1 Site Name and Location

Naval Submarine Base Bangor
1100 Hunley Road
Silverdale, WA. 98315-1199
CERCLIS ID #: WA5170027291

Naval Submarine Base (Subase) Bangor is in Washington State, Kitsap County, in the northwestern portion of the Kitsap Peninsula. The base covers about 7,000 acres in the shape of an approximate rectangle, 6.5 miles north-south by 2.5 miles east-west. It includes five miles of shoreline on the east side of Hood Canal. A 678 acre buffer strip directly across Hood Canal on the Toandos Peninsula, once owned by the base, belongs to the Naval Undersea Warfare Engineering Station (NUWES), Keyport.

Subase is located near latitude 47° 44' 20" N and longitude 122° 44' 15" W. Figure 3-1 is a portion of four-spliced 7.5 minute quadrangle maps for the Quilcene, Lofall, Poulsbo, and Seabeck quadrangles. Concentric circles of 1/4, 1/2, 1, 2, 3, and 4 mile radii are shown, using the base of Delta Pier as origin.

Figure 3-2 is a vicinity map of Subase. Figures 3-3 (a)-(c) are aerial photographs of the base's northern section. Figure 3-4 is a drawing of Subase identifying building numbers, pier and berth designations, etc.

The city of Poulsbo is about four miles east of Delta Pier. The residential community of Vinland is about two and one-half miles northeast. The town of Silverdale is about seven miles south-southeast. The largest city on the Kitsap Peninsula, Bremerton, is about twelve miles south-southeast.

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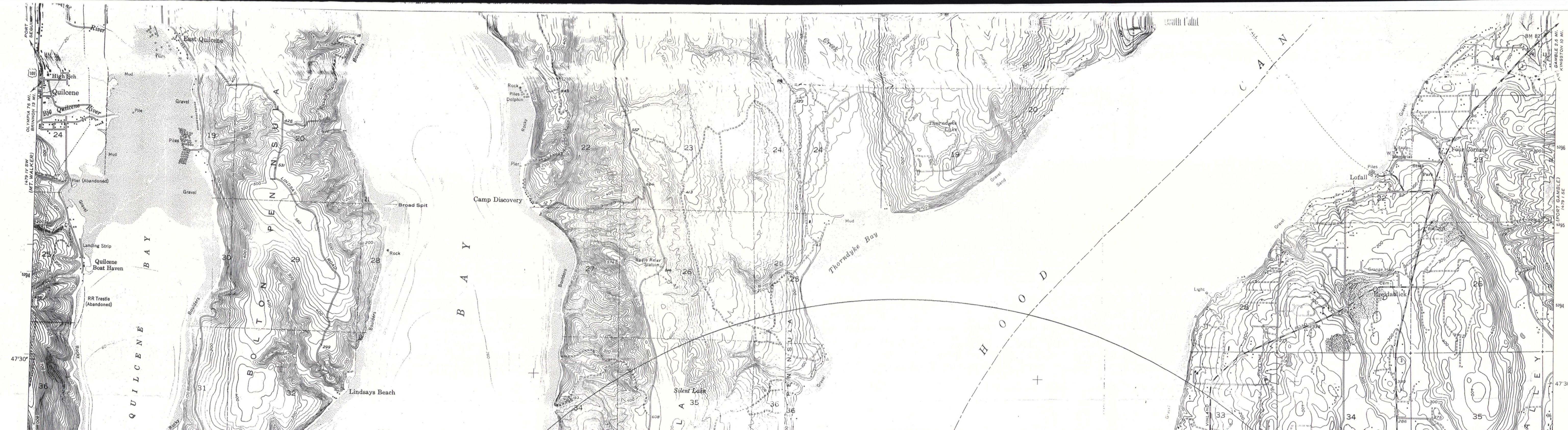


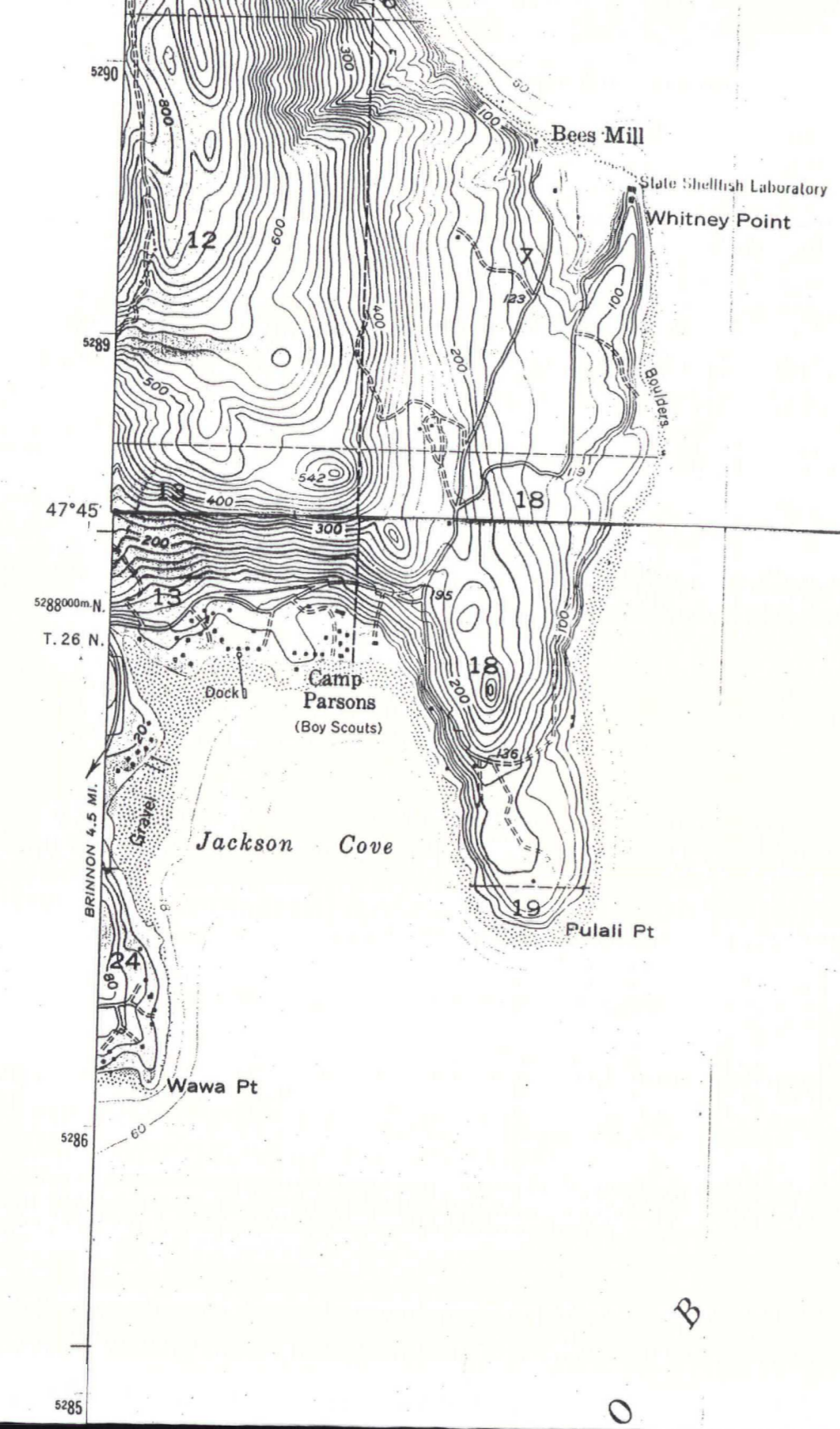
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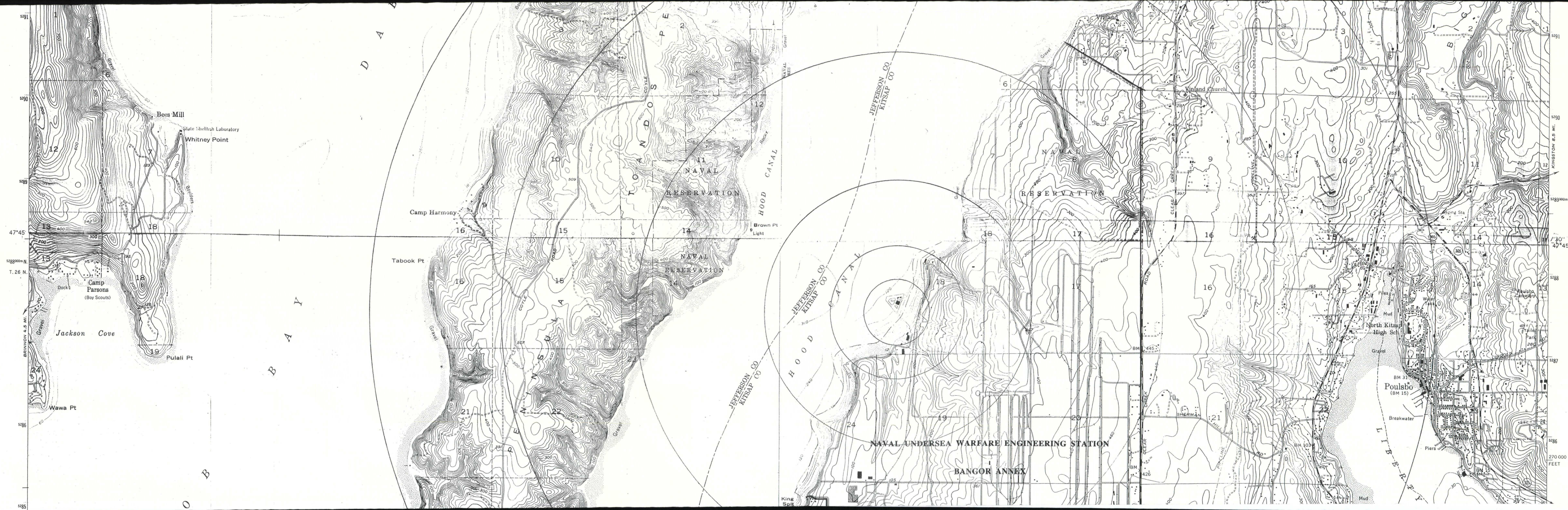
Figure 3-1

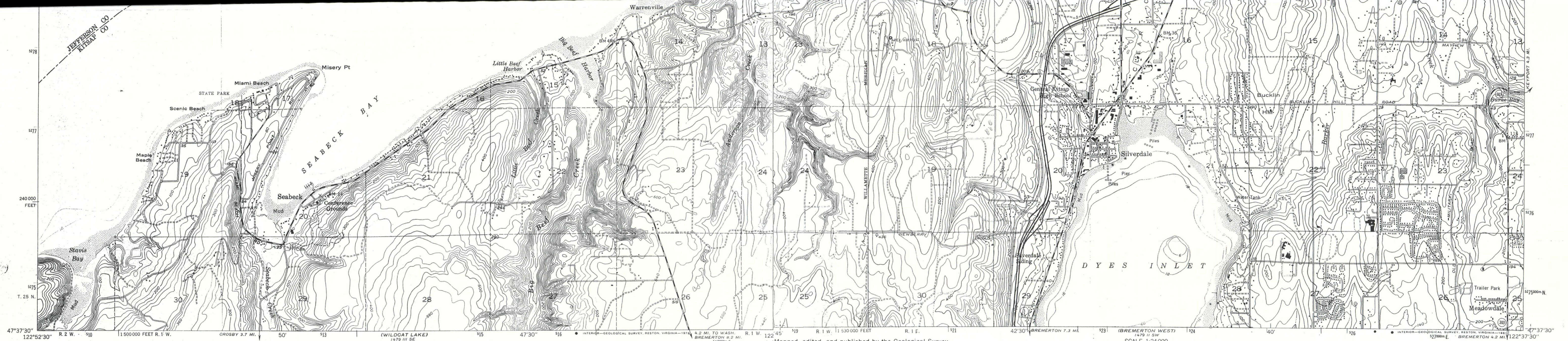


Figure 3-1
7.5 Minute Quadrangle Maps
Circles centered on base of Delta Pier
with radii of 1/4, 1/2, 1, 2, 3, and 4 miles

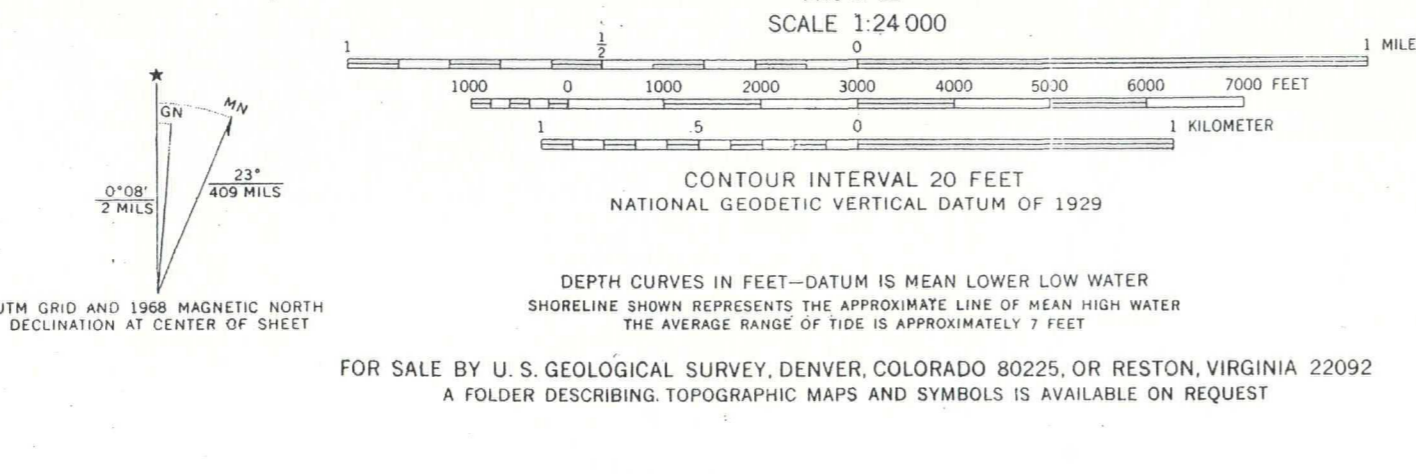






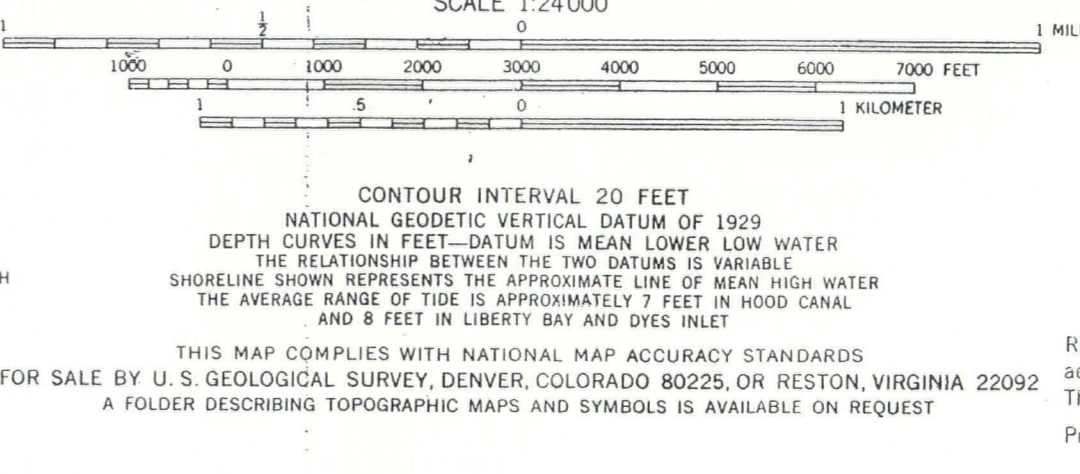


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Aerial photographs taken 1951. Field check 1953
Hydrography compiled from USC&GS Charts 6422 and 6450
Polyconic projection. 1927 North American datum
10,000-foot grid based on Washington coordinate system,
north zone
Dashed land lines indicate approximate locations
1000-meter Universal Transverse Mercator grid ticks,
zone 10, shown in blue
Revisions shown in purple compiled from aerial photographs
taken 1968. This information not field checked

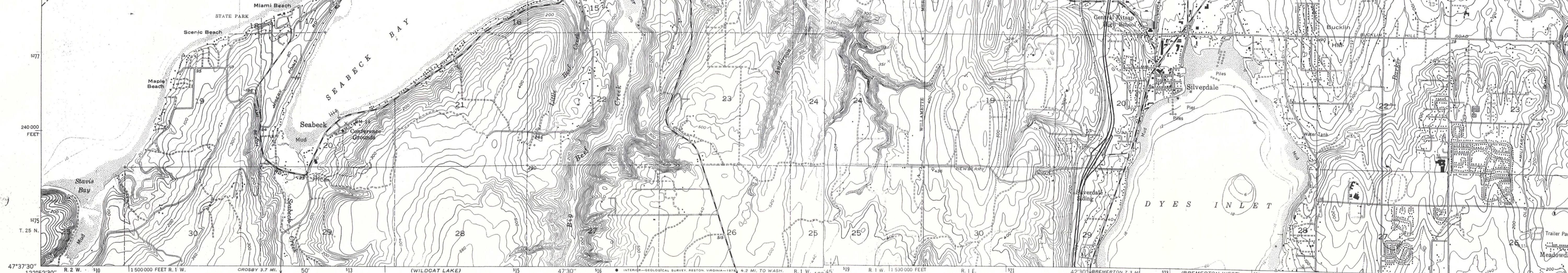


Map photoinspected 1973
No major culture or drainage changes observed

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Washington coordinate system, north zone. 1000-meter
Universal Transverse Mercator grid ticks, zone 10,
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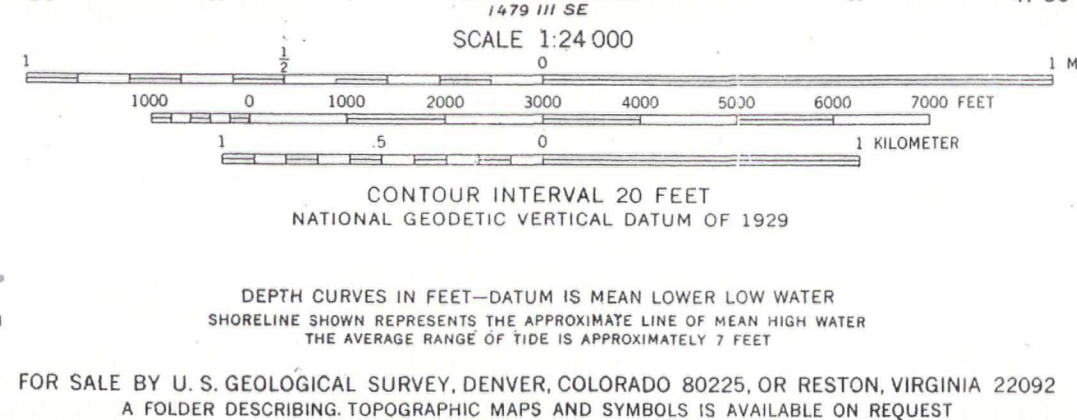
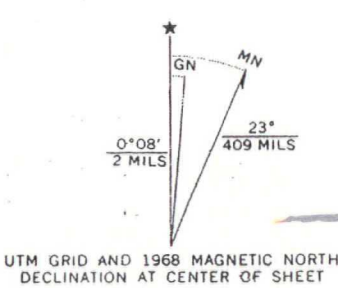


Revisions shown in purple and woodland compiled from
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Purple tint indicates extension of urban areas



(HOLLY)
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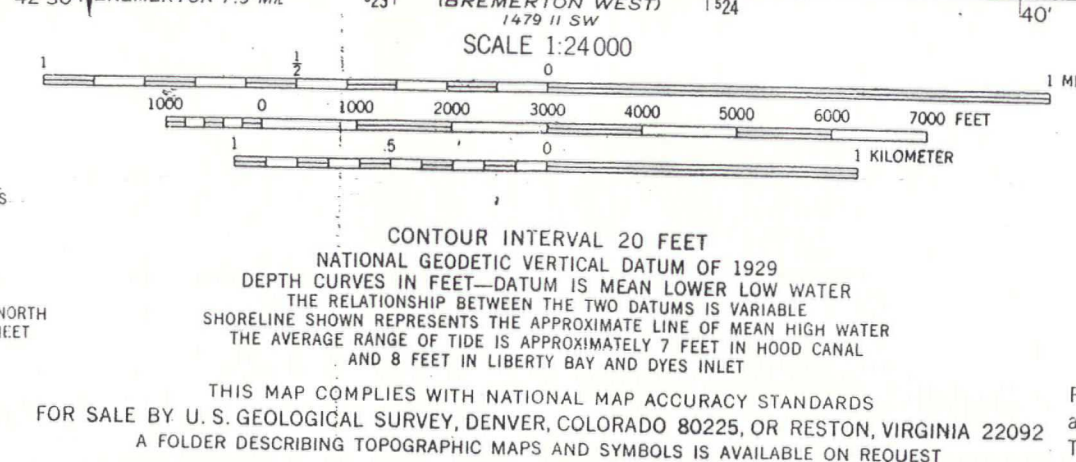
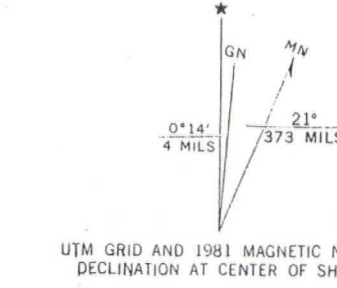
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Polyconic projection. 1927 North American datum
10,000-foot grid based on Washington coordinate system,
north zone
Dashed land lines indicate approximate locations.
1000-meter Universal Transverse Mercator grid ticks,
zone 10, shown in blue
Revisions shown in purple compiled from aerial photographs
taken 1968. This information not field checked



Map photoinspected 1973
No major culture or drainage changes observed

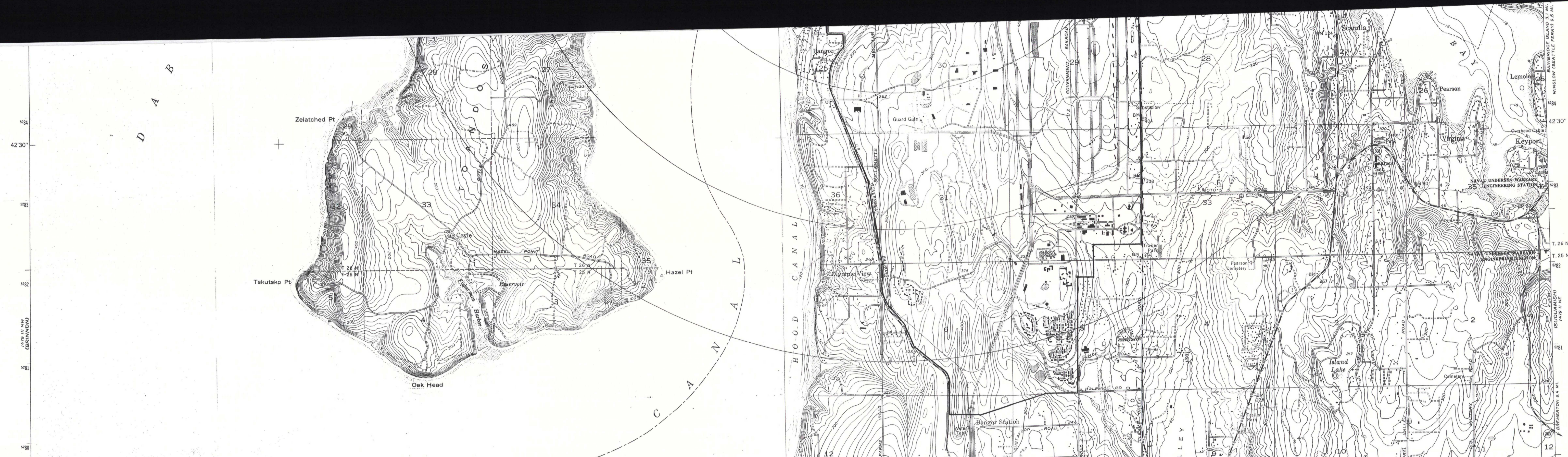
SEABECK, WASH.
NE/4 POINT MISERY 15' QUADRANGLE
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PHOTOINSPECTED 1973
1953
AMS 1479 III NE-SERIES Y891

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Universal Transverse Mercator grid ticks, zone 10,
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east as shown by dashed corner ticks
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N4737.5-W12237.5/
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PHOTOREVISED 1968
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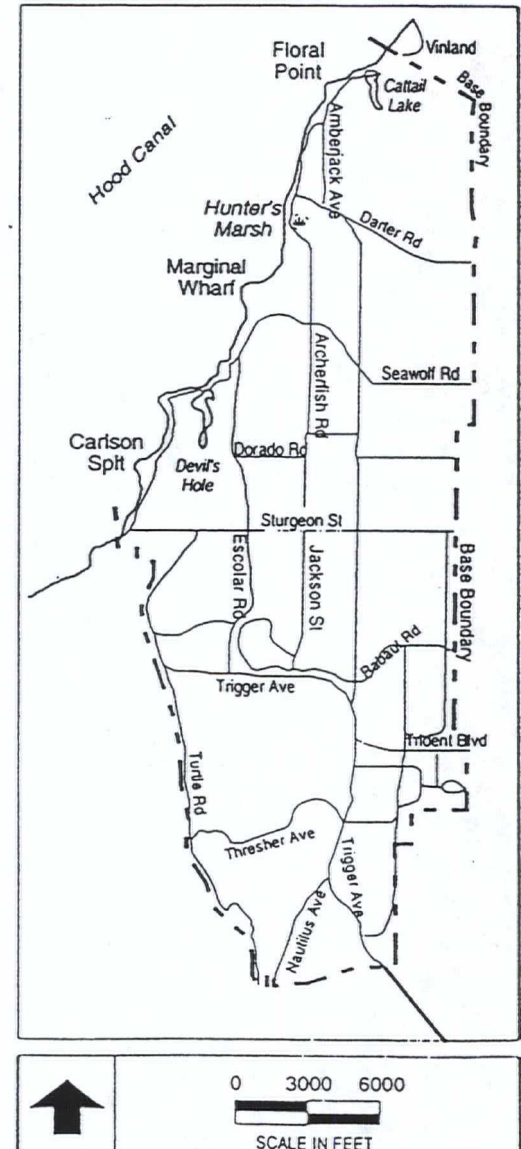
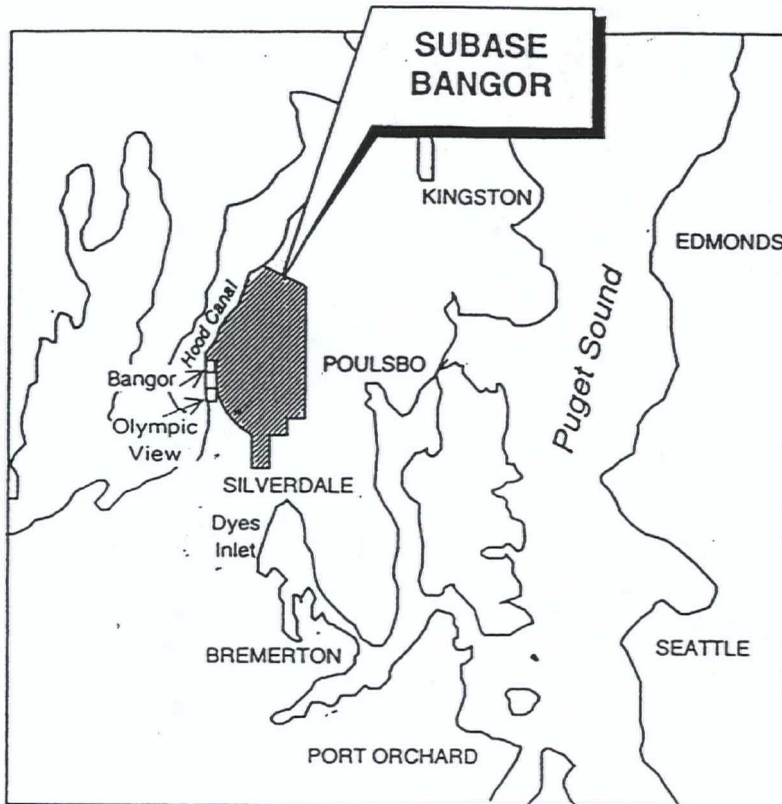


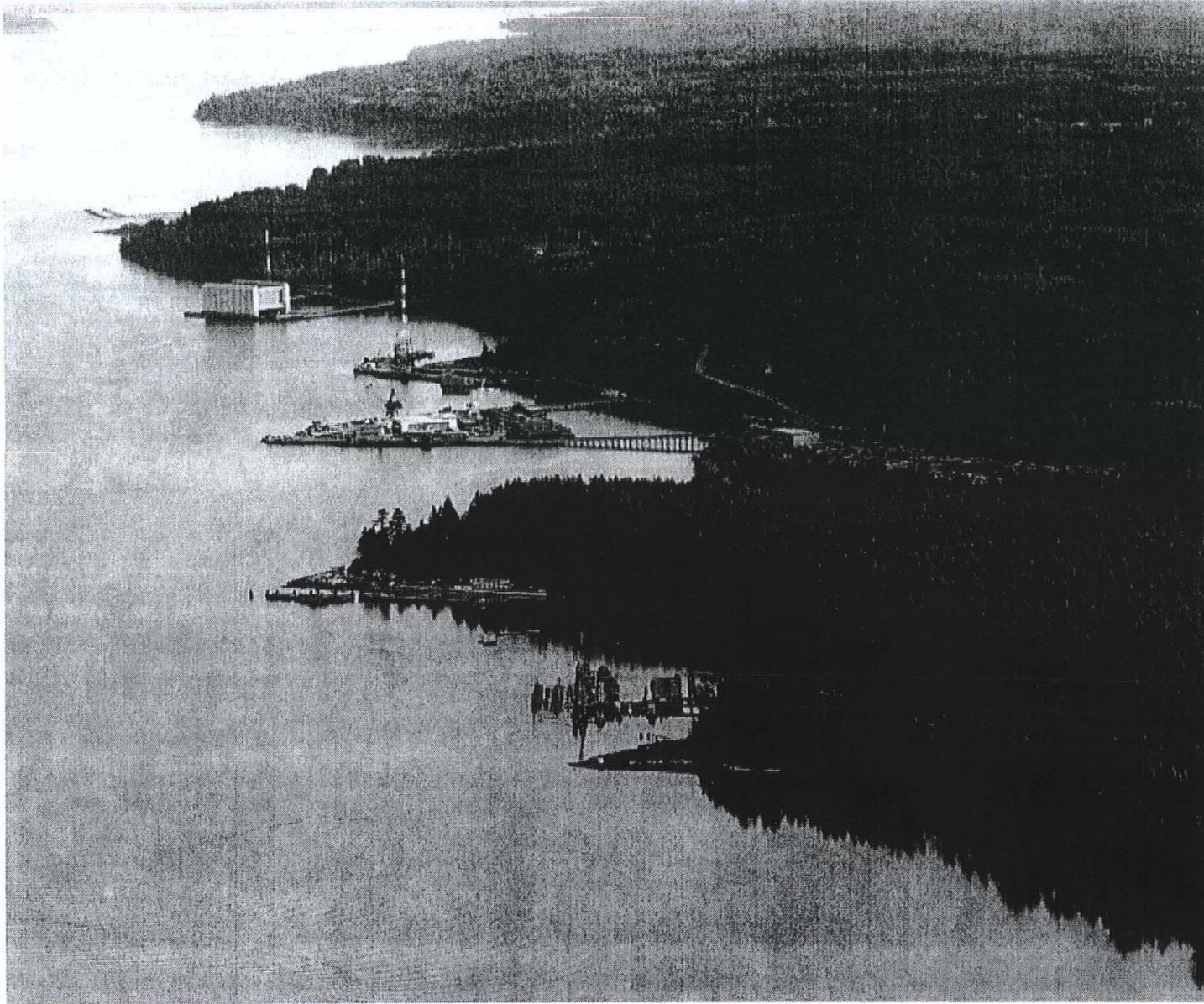
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1479 III NW
(BRINDN)



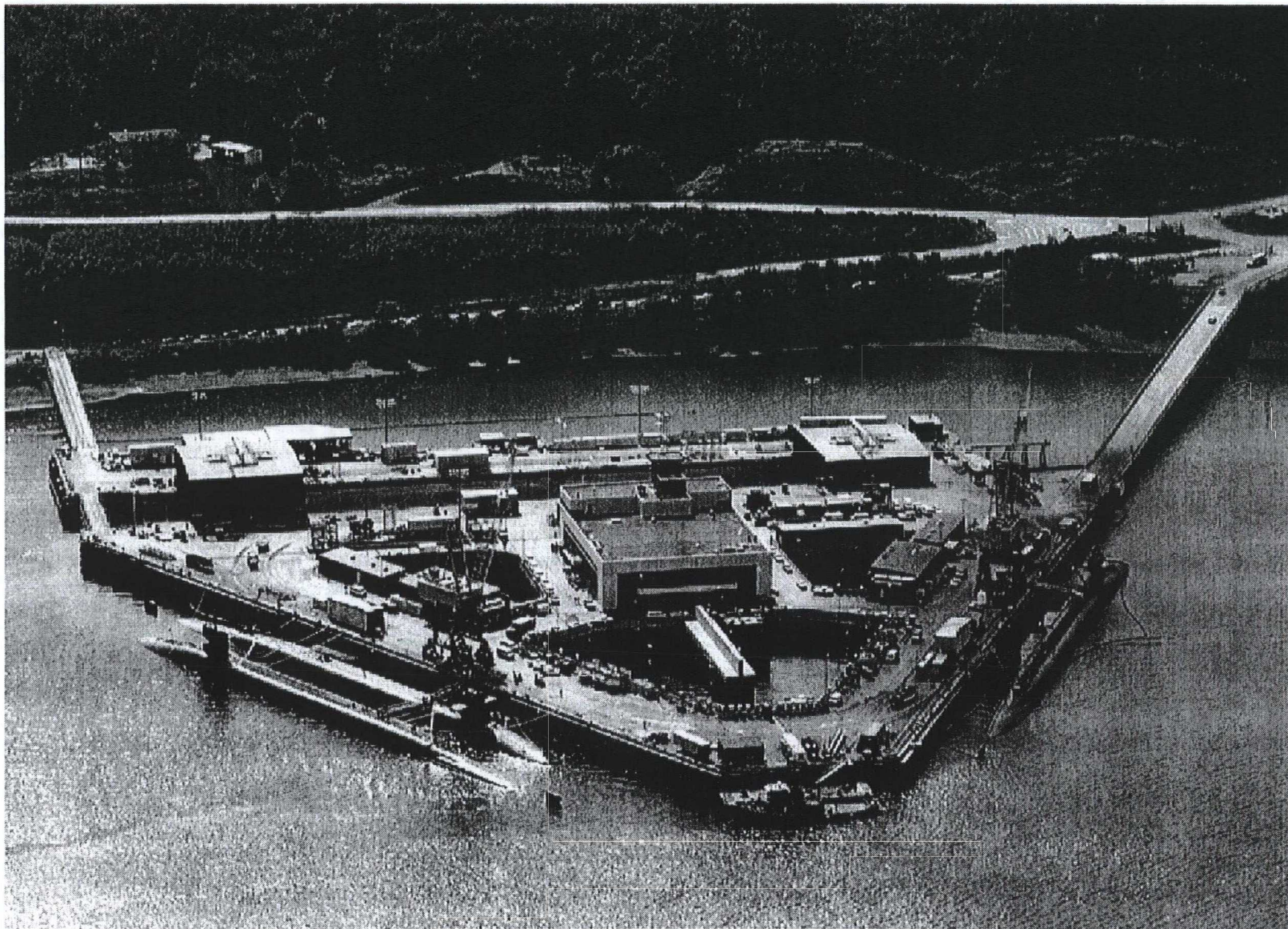
Figure 3-2
Naval Submarine Base Bangor, Vicinity Map





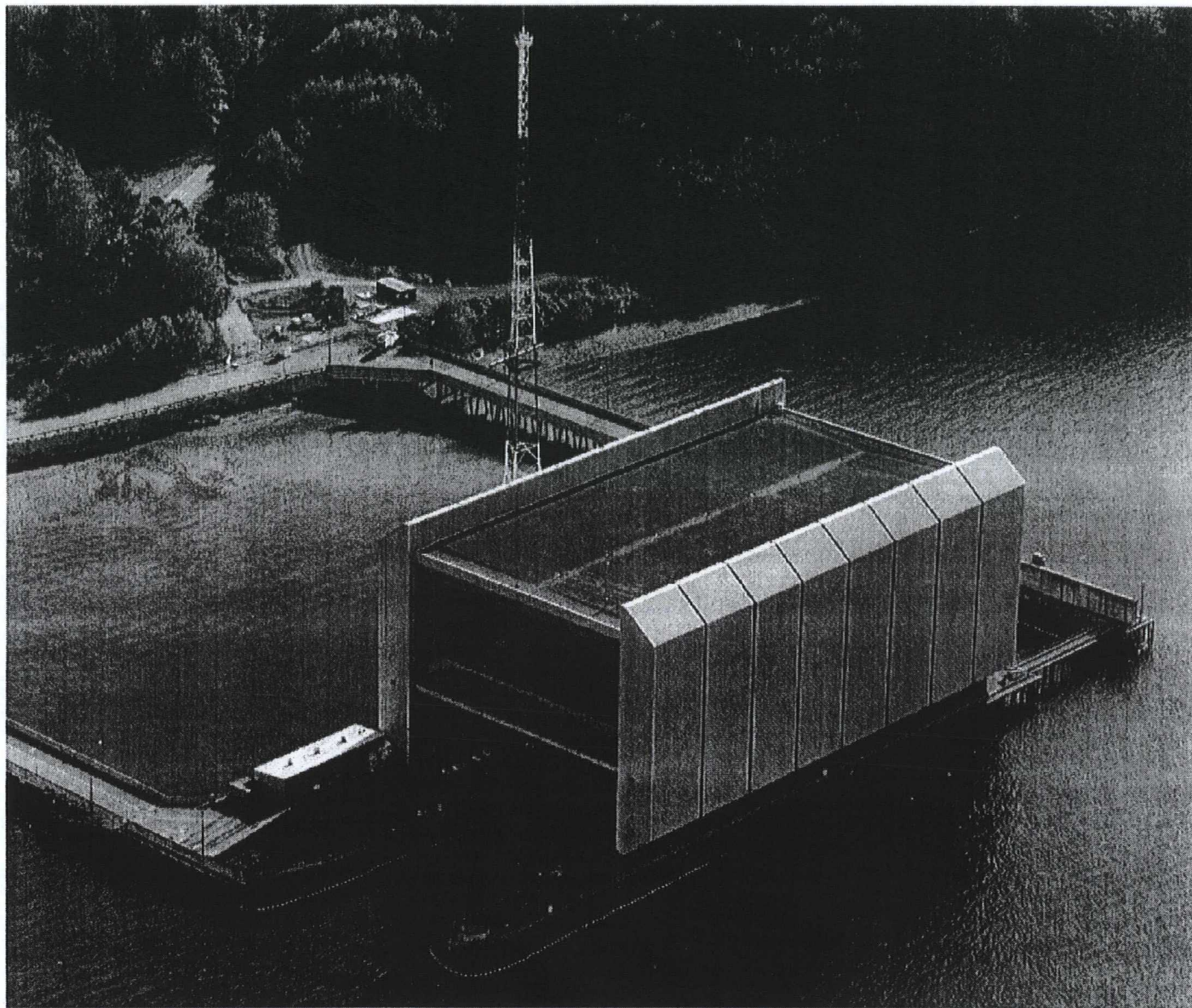
Looking northeast along Hood Canal.

Figure 3-3 (a)



Delta Pier. Looking east.

Figure 3-3 (b)



Explosive Handling Wharf. Looking southeast.

Figure 3-3 (c)

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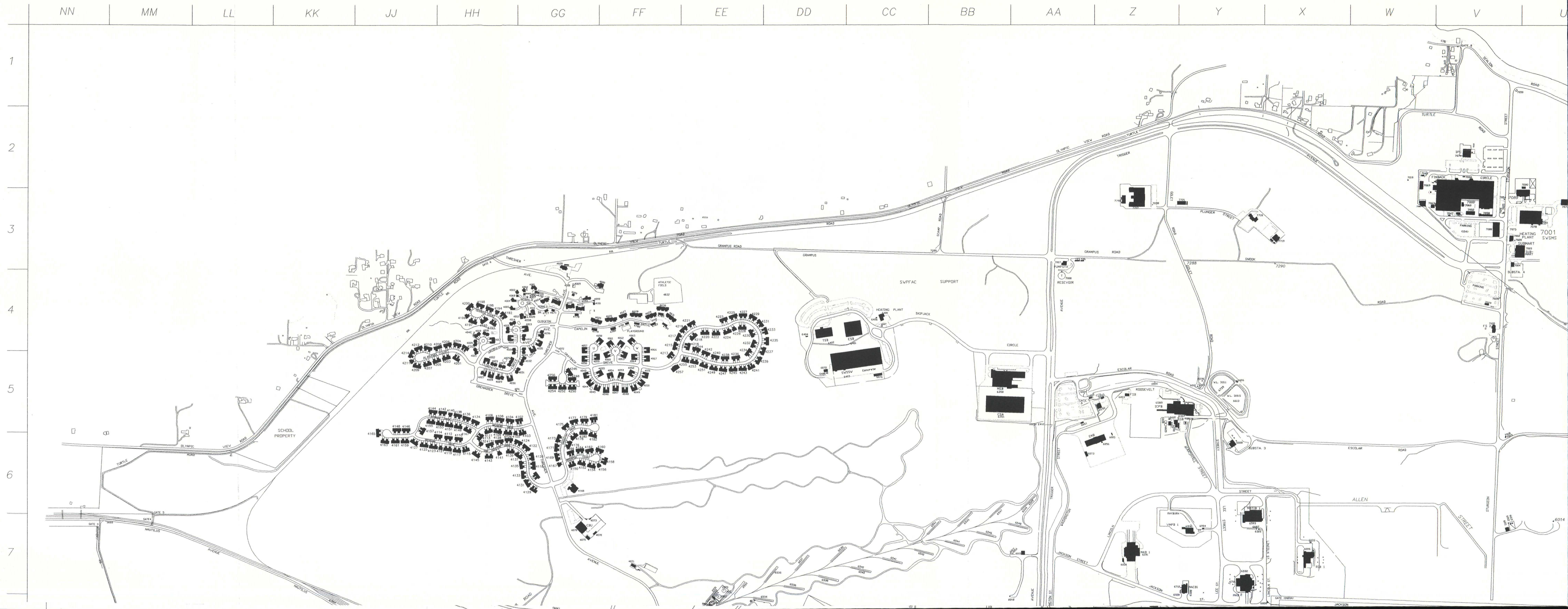
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SITE MAP

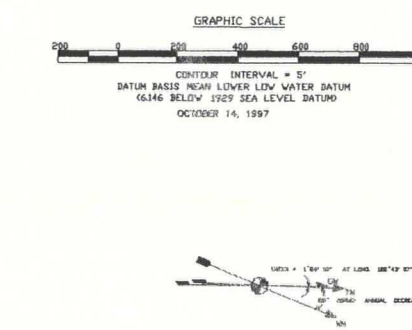
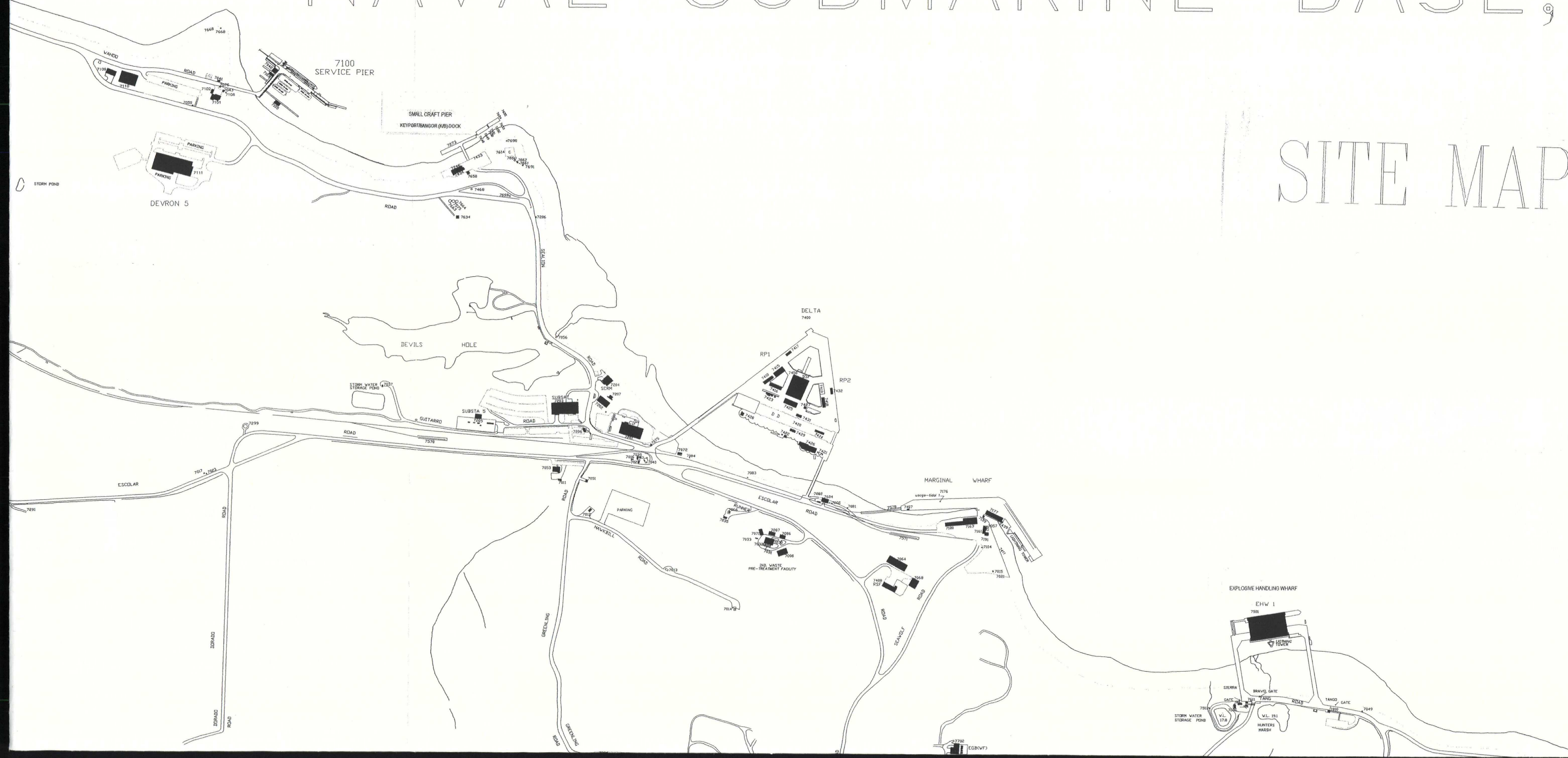
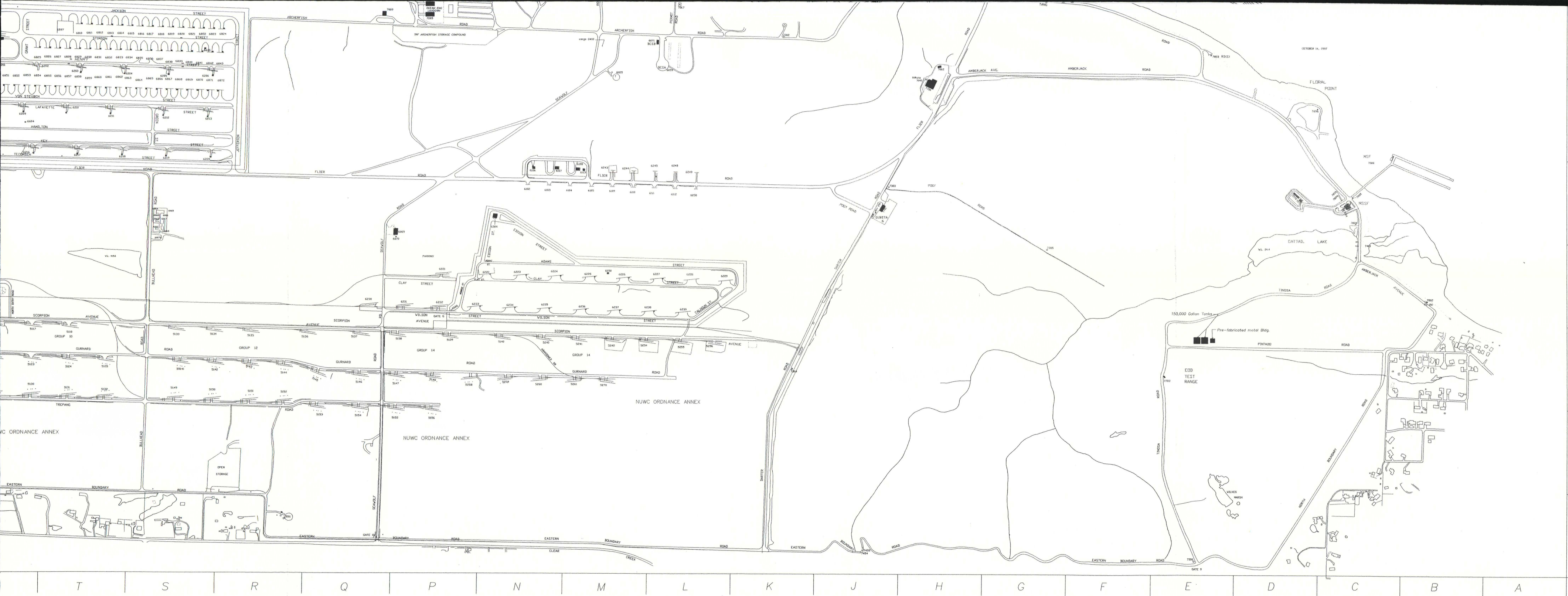
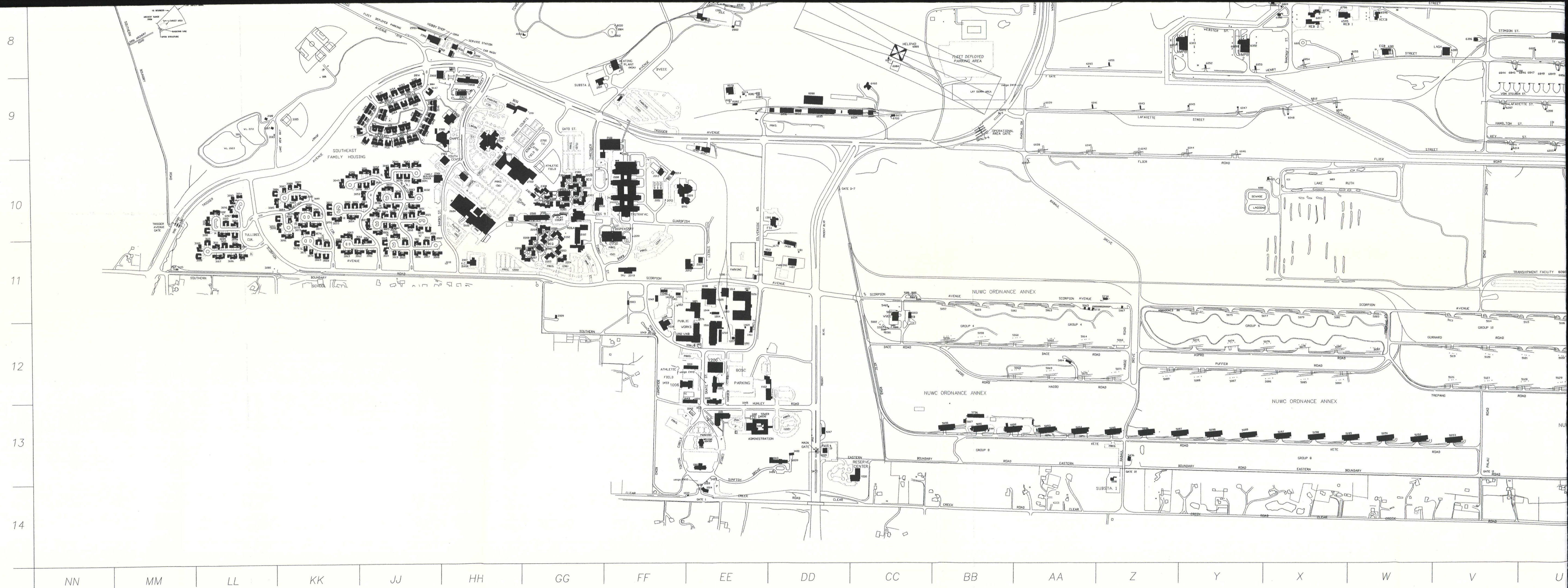


Figure 3-4
Naval Submarine Base Bangor, Site Map



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3.2 Site History

3.2.1 Type of Site

Subase Bangor is a U.S. Navy submarine base. The base, along with its tenant activities, provides intermediate level maintenance, alterations, repairs, and testing on U.S. Navy submarines; home porting of submarines and their crews; and training for submarine personnel. Most of the developed land is in the southern half of the base. The core area is at the extreme southern end of the base with family housing and a community center. The public works and administrative areas are east of the core area. Additional family housing is located west of the core area. Industrial facilities are located throughout the rest of the base. Waterfront facilities are located along the length of the shoreline. The northern part of the base is densely forested and mostly undeveloped. The Bangor site is isolated and is a natural deep water harbor, which permits large ships to tie up at dockside.

3.2.2 Navy Ownership History

On June 5, 1944 the Navy bought 7,676 acres of land on Hood Canal for construction of the U.S. Naval Magazine, Bangor. Before Navy acquisition, the property included a few private dwellings and small farms. The activity was commissioned in August 1945 as the U.S. Naval Magazine Facility, and in 1947 was redesignated the U.S. Naval Ammunition Depot (NAD), Bangor.

NAD Bangor was established by the Navy to provide a deep water transshipment point for ammunition and explosives. NAD Bangor's mission was to receive, renovate, maintain, store, and issue ammunition, explosives, expendable ordnance items, weapons, and technical ordnance material.

For purposes of economy following World War II, NAD Bangor was disestablished and consolidated with the U.S. Naval Torpedo Station (NTS), Keyport, Washington, in July 1950. Following this change, the Depot operated under the management of the U.S. Naval Ordnance Depot, Puget Sound, Keyport, Washington. The consolidation of two dissimilar activities did not prove adequate to meet the requirements and demands placed upon it. Therefore, NAD Bangor was re-established in April 1952 as an independent operating activity.

In 1962, construction of the Polaris Missile Facility Pacific (POMFPAC) was begun. Submarine facilities, including berthing for nuclear-powered ships, were completed in 1963. POMFPAC was commissioned as a tenant at NAD Bangor in September 1964.

In 1970, NAD Bangor was disestablished and consolidated under command of NTS, Keyport, as the Bangor Annex. Bangor Annex was selected as the Underwater Launched Missile System (ULMS; now Trident) support site for the Underseas Long-Range Missile System refit complex in January 1973. In 1974, POMFPAC was renamed the Strategic Weapons Facility, Pacific (SWFPAC) and its scope was enlarged to include support of TRIDENT missiles.

Construction of the Trident support site began in October 1974. This included construction of the Trident Refit Facility which includes the Delta Pier and drydock complex and the Controlled Industrial Facility (CIF), Building 7201. The Trident support site was commissioned as Naval Submarine Base

(Subase) Bangor in February 1977. NTS Keyport was redesignated Naval Undersea Warfare Engineering Station (NUWES), Keyport, in 1978.

Trident Refit Facility's Radiological Controls Department started in January 1979. NNPP headquarters authorized the Trident Refit Facility to perform radioactive work in March 1982. The first Trident submarine to be based here was USS OHIO (SSBN 726), which arrived in August 1982.

3.2.3 Site Activities (Reference 2)

The site has been a Naval ammunition depot since 1945. Ammunition depot activities include loading and off-loading equipment, supplies and ammunition from Naval vessels; ammunition inspection, storage, and transshipment.

Since November of 1973, the primary mission of Subase Bangor has been to provide support to the Trident Submarine Launched Ballistic Missile system, to provide administrative and personnel support for operations of the submarine force, and to provide logistical support for other Navy activities.

In the specific case of G-RAM work, which is the focus of Volume II of this HRA, all of the technical disciplines, trade skills, quality assurance inspectors, and radiological control personnel are available to accomplish work associated with radioactivity. A few of the typical services performed are listed below:

- Industrial radiography
- Calibration of radiation detection instrumentation
- Gas chromatography

Numerous activities support this work such as engineering, planning, supply, electronics, radiological controls, quality assurance, machine shops, and administrative groups required to plan and execute tasks as complex as radiographing a weld within a network of piping in confined spaces on a submarine.

Major tenant commands include:

- Submarine Group Nine and Submarine Squadron Seventeen - Submarine fleet commands
- Trident Refit Facility (TRF)
- Trident Training Facility for submarine crews and TRF personnel
- Home ported Trident submarines
- SWFPAC - Strategic Weapons Facility, Pacific
- Marine Corps Security Force

3.3 Site Description

3.3.1 Site Land Use

Subase Bangor is divided into two functional sections, north and south. The southern section (non-industrial area) of the base is generally administrative and Navy housing. The northern section (industrial area) is used for military operations. Less than 20 percent of the base surface area is covered by buildings, other structures, and pavement.

The piers, barges, drydock, and work facilities used to accomplish industrial radiography and other uses of G-RAM are within the northern section. G-RAM shipments traverse the southern section but are stored within the northern section. As a result of this division, the southern section is not considered a potential source of G-RAM radioactivity entering the environment.

Facilities dedicated to G-RAM work or storage at the shipyard are relatively small. Section 5 presents a detailed listing of facilities which are known to have been used, either currently or in the past, for operations involving G-RAM.

Commercial items in use such as smoke detectors may contain low levels of radioactive material. Current Navy procedures prohibit such items from being disposed of on-site. The potential use of such items is not considered to have spread "G-RAM usage" throughout the base; e.g., housing units are not considered to have been exposed to G-RAM.

A portion of Building 7201 is designated as a G-RAM radioactive material storage area (see Figure 3-4 for location). The TRF Radiation Safety Officer also has a small vault in Room West 115 of Building 7000 which is a designated G-RAM radioactive material storage area.

The remaining buildings in the northern section are shop areas, warehouses, and administrative areas that do not contain radiological material associated with the industrial radiography or other uses of G-RAM. Open paved areas are used for storage of non-nuclear materials and large equipment associated with ship repair functions.

3.3.2 Demography and Adjacent Land Use

Adjacent to the base the country is primarily residential/semirural. Figure 2-11, Land Use Map, of Reference 3 is a detailed color coded land use map of Kitsap County.

The population of Kitsap County in 1990 was 189,731. The following table of estimated population since 1980 shows a pattern that is largely caused by variations in Navy personnel. The estimates were made on April 1 of each year.

Table 3-1
Kitsap County Population

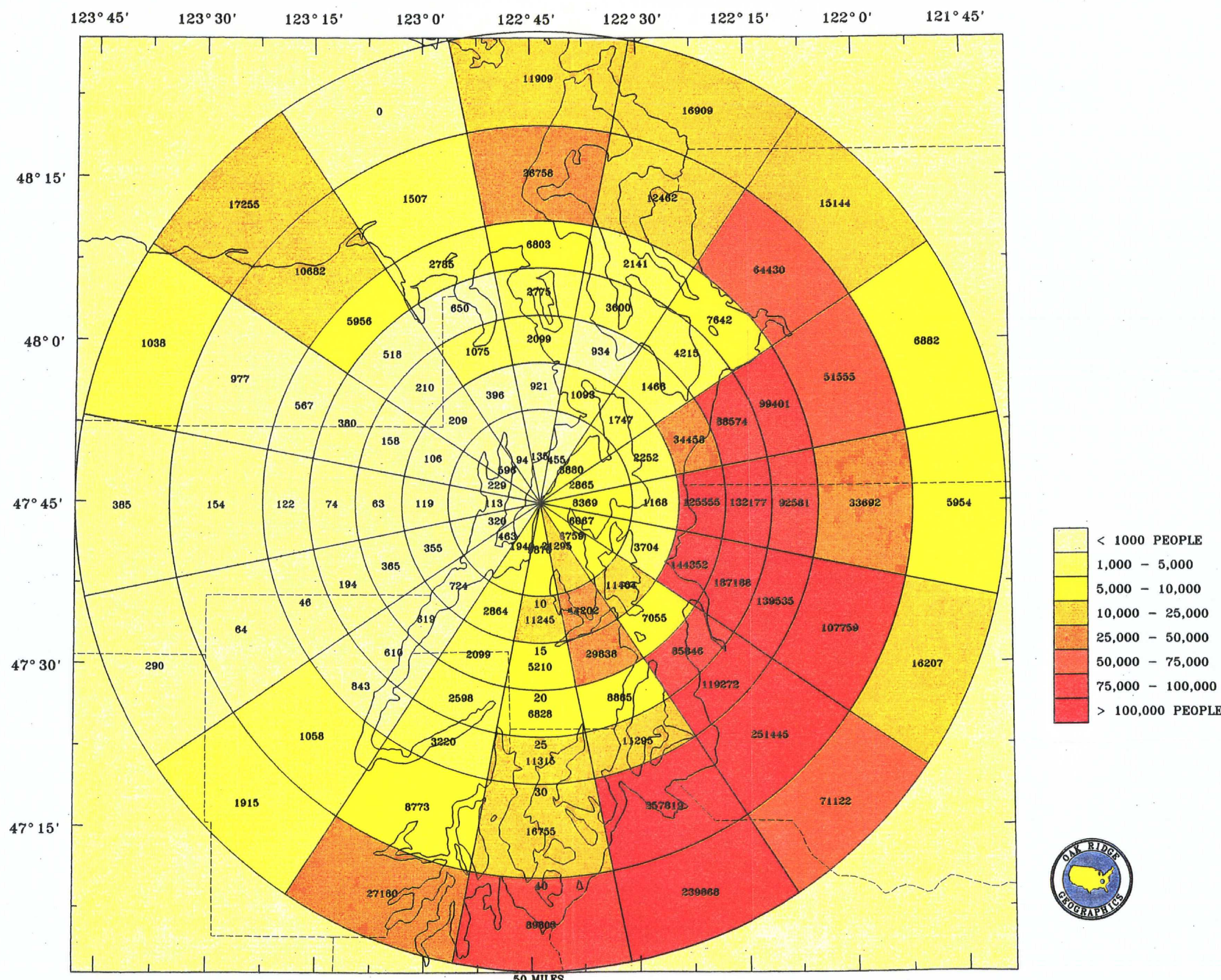
Year	Kitsap County
1980	147,152
1981	156,800
1982	158,500
1983	161,600
1984	162,500
1985	167,800
1986	164,500
1990	189,731

In 1990 the resident Subase Bangor population was 3702. Populated areas near Subase Bangor include the cities of Poulsbo, Keyport, and Silverdale. Small residential communities near the base include Bangor, Vinland, and Olympic View. Bremerton is the largest city in the county with a population of 37,645 in 1992.

At the time of the 1990 census, approximately 2.87 million persons resided within the 50-mile radius from the Subase, with 63,458 within 10 miles.

Figures 3-5 and 3-6 are computer generated constructs of 7.5 minute maps with the population by standard zone and sector divisions overlain. A zone is a 22.5 degree arc with Zone "A" centered on geographic north and Zones B, etc., increasing clockwise. A sector is a one-mile, five-mile, or ten-mile annular segment. Population data is based on the 1990 census data.

1990 Regional Population - SUBABG POPULATION COUNT BY SECTORS AND ANNULI - SUBASE - BANGOR 1990 Census



Population in 10-mile circle

Zone	Population
N	135
NNE	455
NE	3880
ENE	2865
E	8369
ESE	6067
SE	6759
SSE	21295
S	9878
SSW	1940
SW	463
WSW	320
W	113
WNW	229
NW	596
NNW	94

Figure 3-5
 Fifty Mile Population Density

1990 Local Population - SUBABG POPULATION COUNT BY SECTORS AND ANNULI - SUBBASE - BANGOR 1990 Census

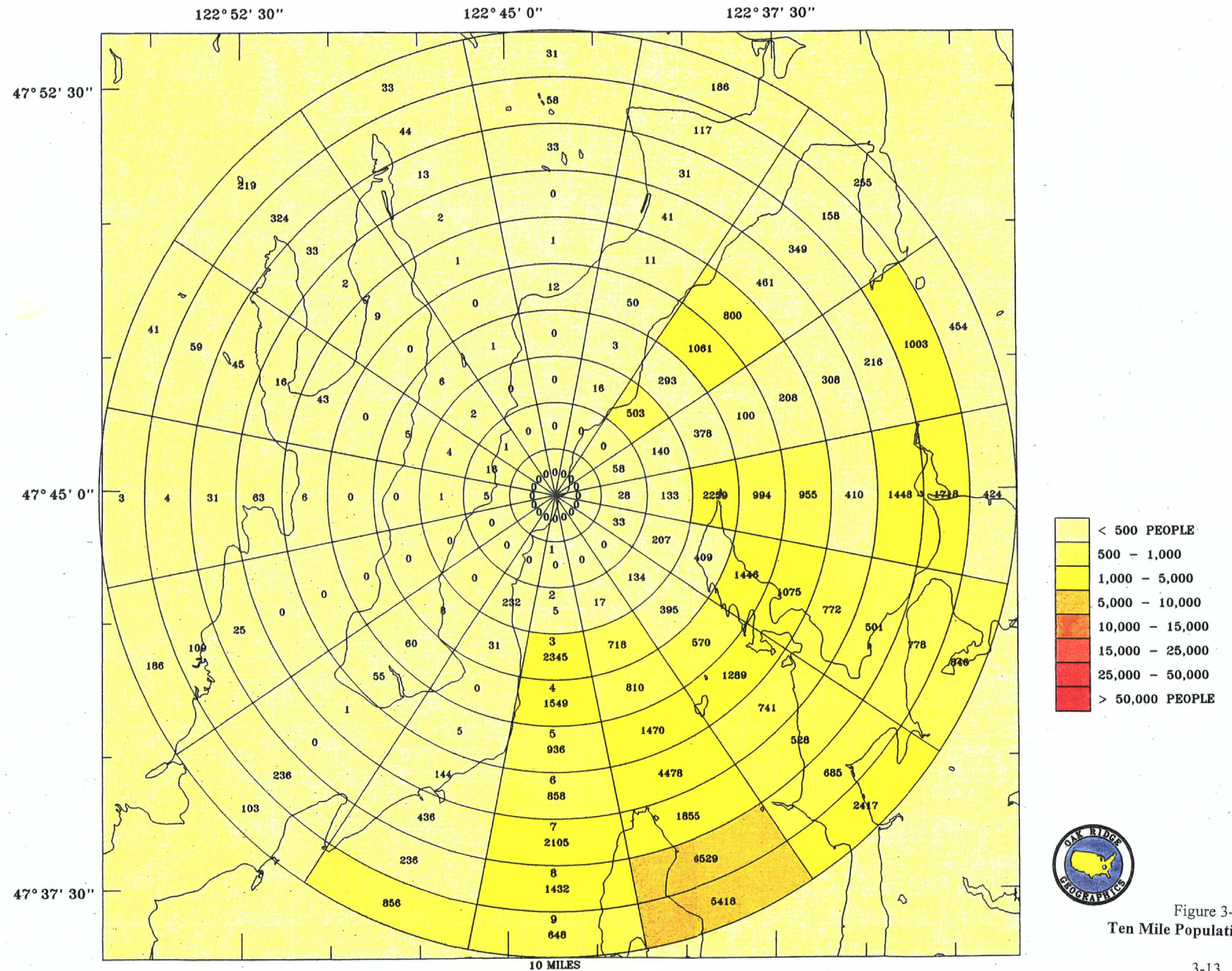


Figure 3-6
Ten Mile Population Density

3.3.3 Physical Characteristics

This section describes Subase Bangor's physiographic setting, soils, geology, hydrogeology, and seismology as they relate to infiltration of contaminants into ground waters, mobility and transport via the ground water, and confining features that inhibit area-wide distribution of introduced potential contaminants. The transport and distribution of materials in the local ground water is, in part, a function of the local and regional geological morphology and stratigraphy.

3.3.3.1 Geology (Reference 2)

Subase Bangor is located on the west side of the Kitsap Peninsula, at the western edge of the central Puget Sound Lowland (also known as the Puget Trough, see Figure 3-7). The lowland is part of a regional north-south trending structural trough extending from the Fraser River Valley in British Columbia to Eugene, Oregon. The Puget Sound Lowland is bounded on the east by the Cascade Range and on the west by the Olympic Mountains. The Kitsap Peninsula separates Puget Sound from Hood Canal, a fjord-like embayment of marine water extending southward from the western end of the Strait of Juan de Fuca. Opposite the base, the Olympic Mountains on the western side of Hood Canal rise to elevations exceeding 8,000 feet, imposing a strong orographic (rain shadow) effect on the regional Pacific maritime climate.

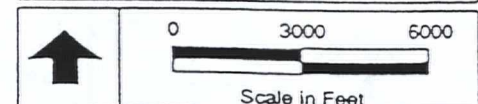
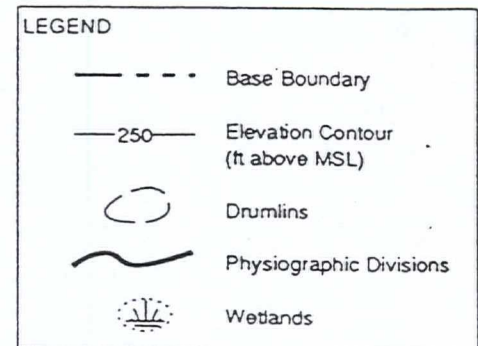
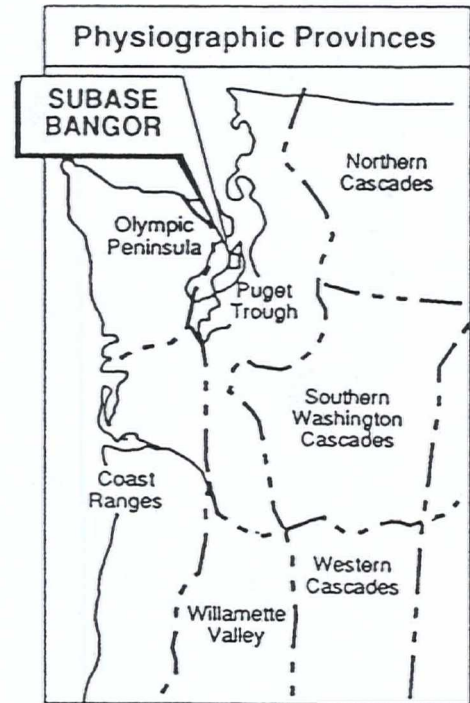
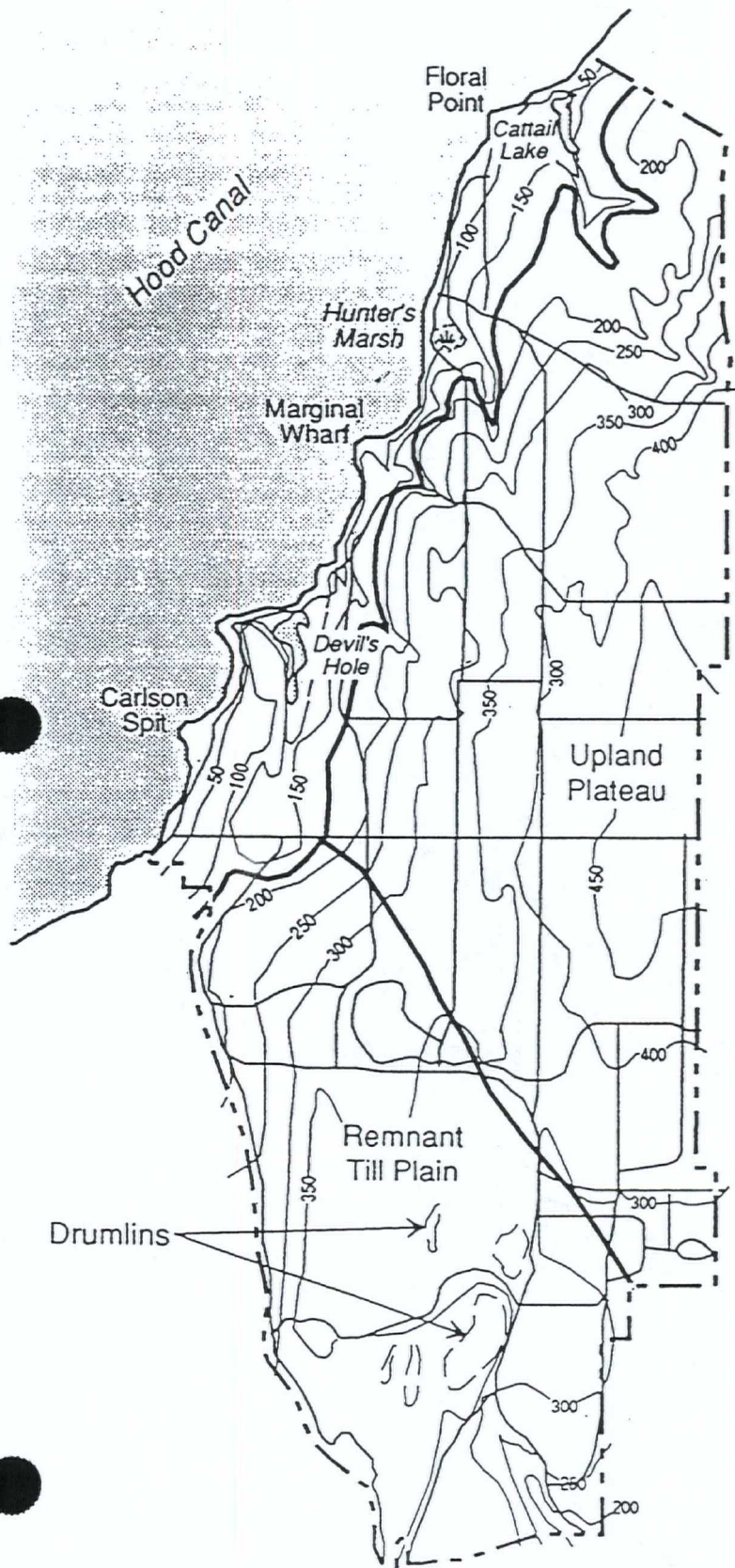
Subase Bangor can be divided into three physiographic areas:

- The upland plateau of the northern part of the base.
- The remnant glacial till plain at the southern end of the base.
- The estuarine and marine environments of Hood Canal.

Subase Bangor rises from sea level to an upland plateau that ranges in elevation from 300 to 500 feet. The western margin of the upland plateau in the northern part of the base is cut by a series of short, straight post-glacial drainages that discharge into Hood Canal. The southern part of the base is a preserved till plain, marked by a number of north-south trending drumlins. [A drumlin is a long, narrow or oval, smoothly rounded hill of unstratified glacial drift.] See Figure 3-7.

Most of Hood Canal has depths at or below 160 feet. Depths along the axis of Hood Canal west of Subase Bangor range from 180 to 380 feet. The 160-foot depth contour lies less than half a nautical mile from the Subase Bangor shoreline, indicating the steepness of the near shore slope.

Figure 3-7
Physiographic Setting of Subase Bangor



The Puget Sound Lowland is a broad structural trough filled with unconsolidated sediments of Miocene to Recent age overlying thousands of feet of early-Tertiary volcanic rocks (primarily basalt). Several major continental ice sheets advanced and retreated across the region during the Quaternary period (0 to 2 million years ago), repeatedly scouring and depositing a complex sequence of glacial and interglacial sediments. The last of these episodes is called the Fraser glaciation. It consisted of multiple minor pulses of ice advance of which the Vashon Stade was the most extensive and during which many of the water bearing strata within the area were deposited. Vashon glacial ice covered the area from approximately 15,000 to 13,500 years ago.

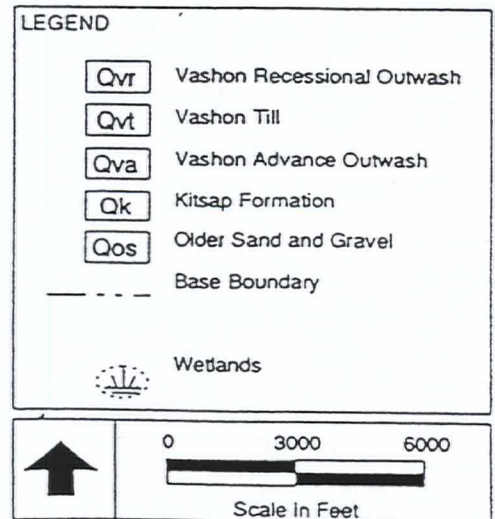
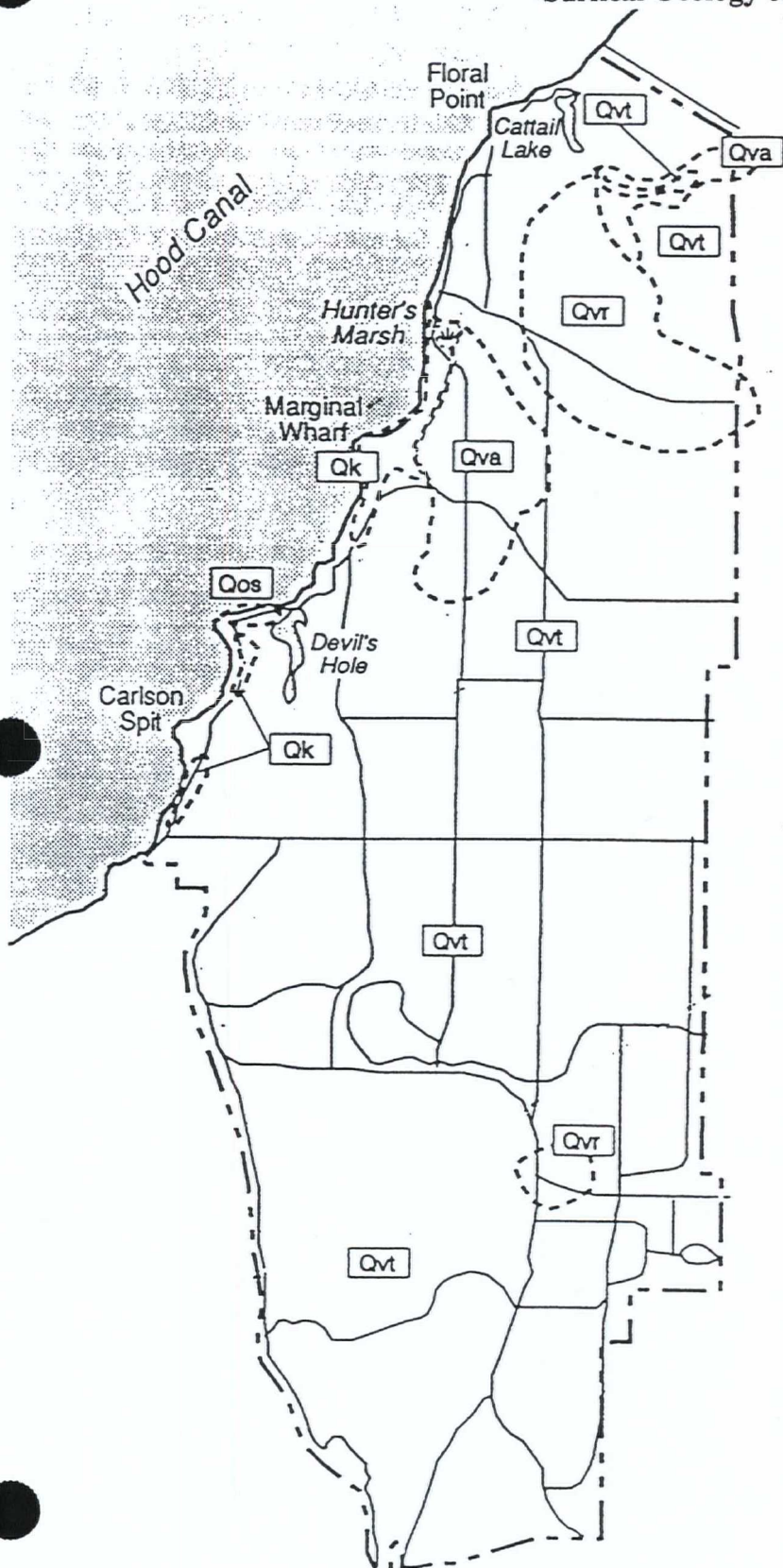
Key aquifers in glacial terrain are typically composed of sands and gravels deposited by streams and rivers of melt water flowing out in front of and to the sides of the glacier as it advances and recedes from the landscape ("outwash"). Also included is glacial till (material scoured, deposited, and compressed by the ice itself) which ranges in size from minute clay and rock flour particles to boulders. Such poorly sorted and over-consolidated deposits tend to impede ground water flow. Typical interglacial strata also include lake and stream deposits and organic-rich peats.

Six stratigraphic units are of particular significance in the hydrogeologic system at Subase Bangor. Their general characteristics are described below. Local outcrop areas of the stratigraphic units, as they occur at Subase Bangor, are shown on the surficial geologic map in Figure 3-8 and in cross section in Figure 3-9.

From youngest to oldest, the six stratigraphic units are:

- **Vashon Recessional Outwash (Qvr)** is a thin, discontinuous veneer of interbedded sand and gravel deposited by melt water from the receding glacier. The deposits are mainly large north-south trending outwash channels. Localized perched aquifers, situated in the depressions cut into the upper surface of the less permeable Vashon Till, provide small quantities of ground water.
- **Vashon Till (Qvt)** is a lodgment till made of a dense, hard, unsorted sequence of sediments ranging in thickness from a few feet to over 50 feet. It consists of variably sized gravel and boulders in a matrix of clay, silt, and sand deposited at the base of a glacier. The overall dense, compact nature of the till hinders ground water flow, making it one of the primary aquitards in the area. It serves as a low permeability base for perched aquifers and the upper boundary for confined ground water zones.
- **Vashon Advance Outwash (Qva)** consists primarily of coarse sands and gravels beneath the Vashon Till. A typical sequence consists of poorly sorted gravels at the top grading down to well-sorted, stratified sands and gravels with localized lenses of lacustrine clay. ("Lacustrine" means formed at the bottom of or along the shore of a lake.) This unit is highly permeable and may yield large quantities of water where it extends below the regional water table.
- **The Kitsap Formation (Qk)** consists of laminated silt and clay with an occasional layer of sand and gravel deposited in an interglacial lacustrine environment. The maximum thickness reaches 150 feet, with the top of the unit normally below sea level. An unnamed gravel is commonly associated with the top of the Kitsap Formation. The gravel unit consists of iron-stained, poorly bedded, fine to cobble gravels derived from the Olympic Mountains to the west and reworked granite pebbles from older glacial tills. The Kitsap Formation and the unnamed gravel yield small supplies of ground water.
- **The Older Sand and Gravel (Qos)** incorporates the Salmon Springs Drift and pre-Salmon Springs deposits which are undifferentiated. The Salmon Springs Drift consists of interbedded coarse gravels and sands deposited in a fluvial environment with local occurrences of glacial till. Pre-Salmon Springs deposits, undifferentiated, include both glacial and non glacial, fine-grained sands, silts, and clays. The top of these sediments occurs near sea level while the base has seldom been encountered. The combined thickness is believed to be over 200 feet. The coarser-grained Salmon Springs Drift is capable of supplying large quantities of artesian ground water. It is the most important ground water unit on the Kitsap Peninsula.
- **Tertiary Volcanic Bedrock** underlies these deposits and is predominantly basalt. The total thickness of these rocks is not known but exceeds 7,000 feet. The dense and extremely impermeable character of these rocks renders them unimportant as aquifers.

Figure 3-8
Surficial Geology of Subbase Bangor





3.3.3.2 Soils (References 1 and 3)

Kitsap County has four basic soil types:

- Soils underlain by cemented hardpan or bedrock substrate (Alderwood, Harstine, Sinclair, Edmonds, and Melbourne series).
- Soils with permeable, distinctly stratified substrata (Everett, Indianola, and Kitsap series).
- Organic soils represented by small, widely scattered areas of Greenwood, Mukilteo, Rifle, and Spalding peats and muck.
- Soils having little or no agricultural or building potential. Typical land forms include rough mountainous land, steep broken land, coastal beaches, and tidal marshes.

The most common surface soil in the northern section of the base is the Alderwood series - a very gravelly sandy loam with a percolation rate between 2.0 and 6.0 inches/hour. The depth to the hardpan ranges from 20 to 40 inches.

3.3.3.3 Ground Water Sources and Uses (References 1, 2 and 3)

Subase Bangor has four distinct superimposed aquifer systems. In order of increasing depth they are the Perched Aquifer, Semi-Perched Aquifer, Sea Level Aquifer, and Deep Aquifer. Contaminants, if present, could enter the Perched Aquifer through direct recharge from precipitation, and possibly the lower aquifers via leakage through overlying layers. The Perched and Semi-Perched Aquifers are used for potable water supplies in areas adjacent to Subase Bangor. The base obtains its water supply from the Sea Level Aquifer.

The Perched Aquifer and Semi-Perched Aquifer are identified in Figure 3-9 as the Shallow Aquifer and the Intermediate Groundwater Zone, respectively.

Beneath the base, the average thickness of the Perched Aquifer is approximately 70 feet. The saturated zone extends from approximately 130 feet to 200 feet below the surface. The Perched Aquifer appears to be a semi-confined system on a regional basis. For Subase Bangor the gradient of the Perched Aquifer is very flat (less than 6 inches in one-half mile). At Floral Point, and by inference for the whole near shoreline area, the Perched Aquifer flows parallel to topography outward into Hood Canal. Flow directions for deeper aquifers below the base are not known.

The Sea Level Aquifer occurs at elevations ranging from slightly above mean sea level to approximately 300 feet below mean sea level. The aquifer thickness ranges from a few feet to more than 300 feet. The confining aquitard ranges in thickness from a few feet to more than 200 feet. The piezometric surface of the sea level aquifer is above the top of the aquifer and, in lowland areas, the wells are flowing artesian.

The Sea Level Aquifer and, to a lesser extent, the Deep Aquifer are influenced by tidal fluctuations in Hood Canal. Sea water is in direct contact with the aquifers at points where submarine springs exist; however, the primary mechanism of tidal influence is the weight of the water transmitted through overlying formations. Compression of the aquifer causes the potentiometric surface to rise and fall with the tide.

Local precipitation is the primary source of water recharging the aquifers. Most of the precipitation occurs during the winter months of November through April. Precipitation and subsequent infiltration recharges the Perched Aquifer by downward percolation through the till. Regionally, the recharge to the intermediate ground water zones is by flow from the Perched Aquifer as indicated by downward vertical gradients.

The chemical quality of most ground water throughout the region is good to excellent. The relatively high annual precipitation rate (47 inches per year) results in low dissolved solids in the ground water, typically less than 150 milligrams per liter (mg/L). However, shallow wells very near the shoreline may have high chloride concentrations because of saltwater intrusion.

Water Supply

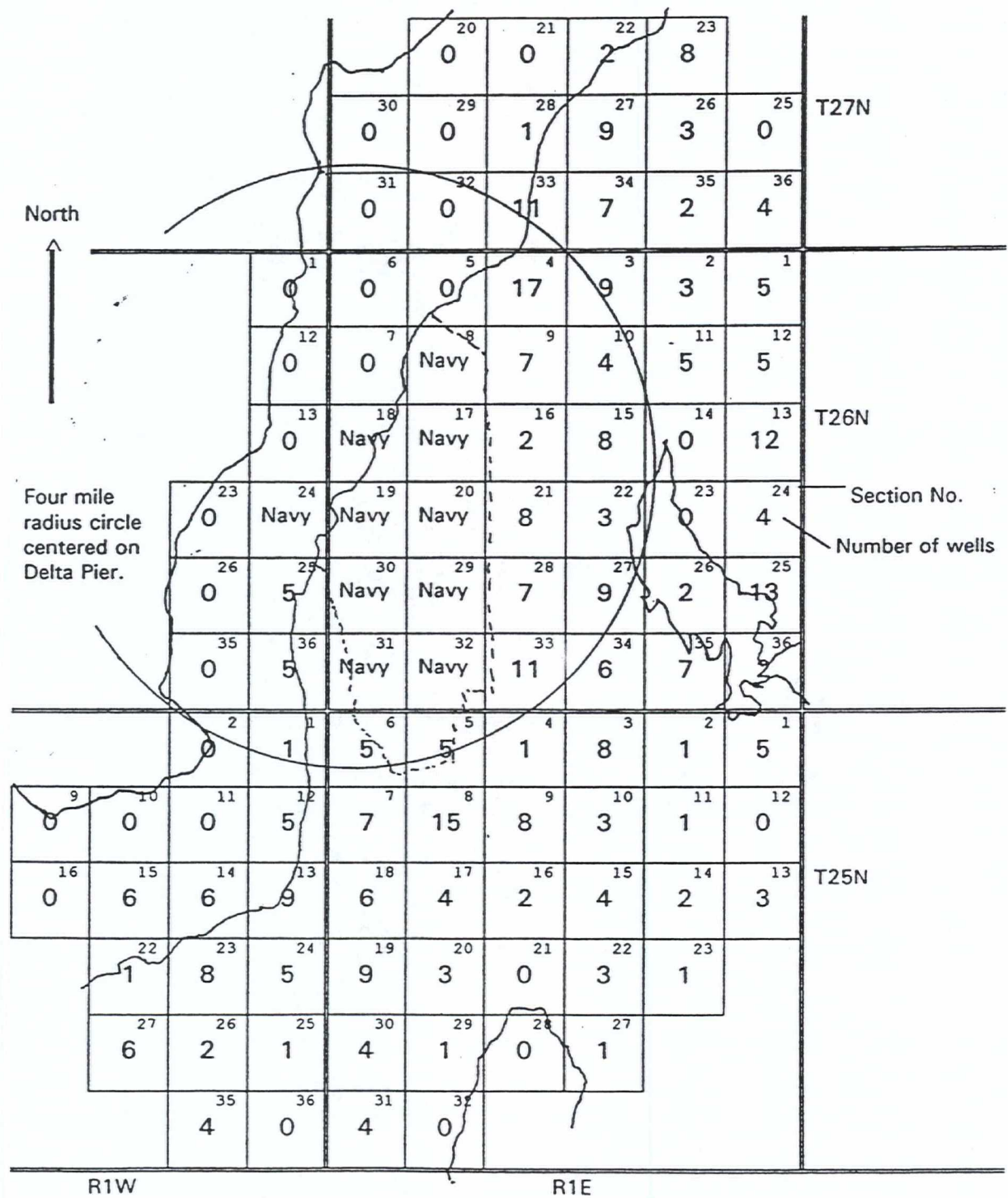
Three Sea Level Aquifer wells on the base provide all of Subase Bangor's drinking water. The three wells are on Hawkbill Road (grid N-6 on Figure 3-4). In addition there is a well in the Strategic Weapons Facility Pacific production area (Figure 3-4, grid Y-5) which is not in use, and one well near Fire Station #1 on Silversides Road (nonchlorinated well) which is used for irrigation (Figure 3-4, grid DD-10). Subase Bangor's drinking water wells supply water to approximately 13,000 people, including residents, employees, and Fleet personnel.

Subase Bangor supplies potable water to one off base user - the Clear Creek School. The function of supplying potable water to Clear Creek School will be taken over by the Silverdale Water District in early 1996.

There are numerous wells near the base: Kitsap County PUD #1 has a potable well in Vinland, the Silverdale Water District has a potable well near the southeastern portion of the base, and the community of Olympic View has two wells.

Figure 3-10 shows the number of drinking water systems (i.e., wells) in each township section within four miles of Subase Bangor in Kitsap County. There are a total of 368 wells represented in Figure 3-10. One-third are within four miles of Delta Pier (Reference 4).

Figure 3-10
Drinking Water Systems by Section
Within Four Miles of Subase Bangor, East of Hood Canal



Legend: Navy = Subase Bangor

3.3.3.4 Surface Water Sources and Uses (References 1 and 2)

The region's typical lowland type streams and creeks have moderate gradients. The watersheds of the west half of Kitsap Peninsula drain into Hood Canal. Those on the east half of Kitsap Peninsula drain into Puget Sound. The highest flows are from November to February, and the lowest flows are during August and September. The streams are not large enough to pose significant flood hazards, but flooding of the low-lying areas adjacent to these streams does occur during extraordinarily high tides or wave action.

Surface drainage provides a primary link between the terrestrial and marine ecosystems that make up Subase Bangor; for example, Devil's Hole harbors immature salmon before they migrate into Hood Canal. Further, areas of extensive development and paving, such as the Controlled Industrial Facility, magnify the proportion and intensity of surface runoff from precipitation events.

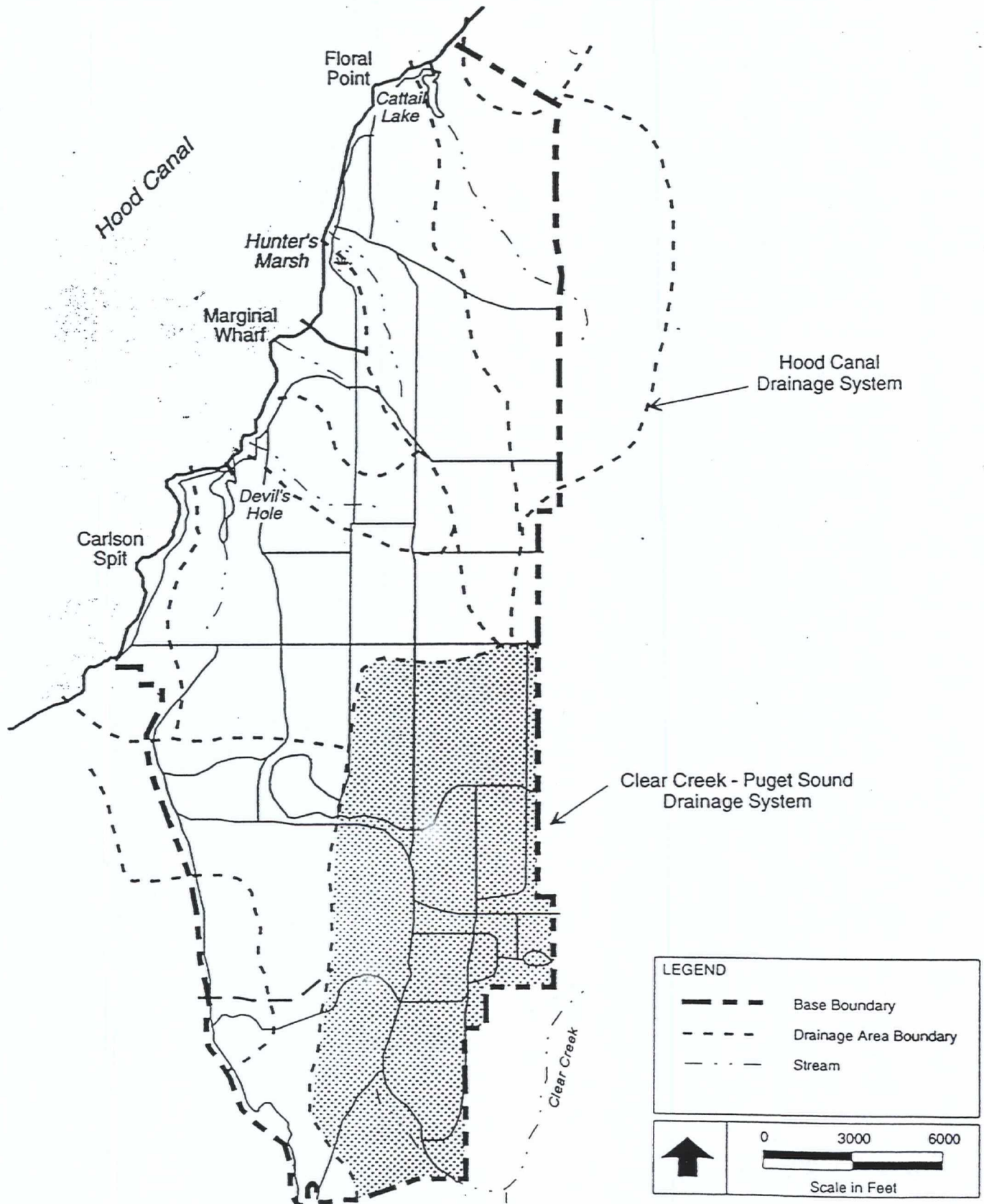
The Trident Support Site Environmental Impact Statement (U.S. Navy 1974) identified 15 small streams affected by Subase Bangor. Recorded stream flows range from 0.01 cubic feet per second (cfs) to 4 cfs derived from a 2.07 square mile drainage area for the stream passing through Devil's Hole. Drainage areas for the streams vary from 0.03 to 3.68 square miles.

Two drainage systems are recognized within Subase Bangor boundaries (Figure 3-11). The northern and western portions of the base feed the post-glacial drainages that discharge into Hood Canal. The southeastern corner of the base lies within the tributary system of Clear Creek, and drains into Dyes Inlet and Puget Sound. The surface sediments are coarse, unconsolidated, and highly permeable deposits into which surface water infiltrates rather than forming overland runoff.

Five short, straight, post-glacial drainages incise the margins of the upland plateau in the northern half of Subase Bangor (Figure 3-11). These drainages lack tributary systems and have a typical length of just over a mile. Their outlets into Hood Canal are spaced approximately one-half to one mile apart. Three of these drainages have been artificially dammed by shoreline road construction, creating Devil's Hole, Hunter's Marsh, and Cattail Lake. Overland flow from much of the western portion of Subase Bangor is routed to Hood Canal through a series of storm water outfalls.

Clear Creek and its tributaries form the best-developed drainage system in the area, draining the southeastern corner of Subase Bangor and covering approximately 750 acres. The west branch of Clear Creek (including the intermittent middle fork) originates on Subase Bangor. The east branch does not receive flow from the base. The combined Clear Creek drains into Dyes Inlet near the town of Silverdale.

Figure 3-11
Surface Water Hydrology



The most commercially important migratory fish species in Hood Canal is chum salmon, followed by chinook, coho, and pink salmon. While wild salmon stocks still occur in Hood Canal, the fishery is largely dependent on stocks produced by several hatcheries in the area. Commercially important resident groundfish species include English sole, rock sole, Pacific cod, surfperch, and dogfish. There are Pacific herring spawning grounds in areas of north and south Hood Canal.

Intertidal and subtidal shellfish populations in Hood Canal also support significant commercial and recreational fisheries. Predominant species are oysters, geoducks, Dungeness crab, shrimp, horse clams, butter clams, and Manila littleneck clams.

Subbase Bangor's freshwater wetlands are sensitive environments. They cover about 460 acres and include three major wetlands: Devil's Hole, Cattail Lake, and Hunter's Marsh.

Washington State uses a four-tier wetlands rating system with Category I as the highest ranking. Devil's Hole (Category I) is a man-made lake located south of Delta Pier. Its 22 acres provide habitat for released salmon to mature before they migrate into Hood Canal.

Cattail Lake (Category II) is a man-made lake located southeast of the Magnetic Silencing Facility. Its 12 acres provide habitat for the three-spine stickle-back, freshwater sculpin, German brown trout, brook trout, and large mouth bass. A beaver family inhabits the stream draining into the lake.

Hunter's Marsh (Category II) is east of the Explosives Handling Wharf. Its 3 acres support a large population of spiders, insects, tree frogs, and waterfowl.

Cattail Lake and Devil's Hole have supported reproducing pairs of osprey since the early 1980's. Additional sensitive environments include forested areas, eel grass beds, and Great Blue Heron rookeries.

Because Hood Canal is saline it is not used for drinking water. There are no water systems with surface water intakes within Subbase Bangor. The base includes almost all of the Hood Canal Drainage System (See Figure 3-11). The Silverdale Water District, south and southeast of the base, does not use surface water.

Figure 3-12, Surface Waters With Domestic Water Rights, lists by township-range all named surface waters with domestic water rights within the 15 mile target distance limit. In most cases the listed surface waters are used by only a few (one to three) households. The 15 mile target distance limit also includes unnamed streams, springs, and ponds.

Figure 3-12
Surface Waters With Domestic Water Rights

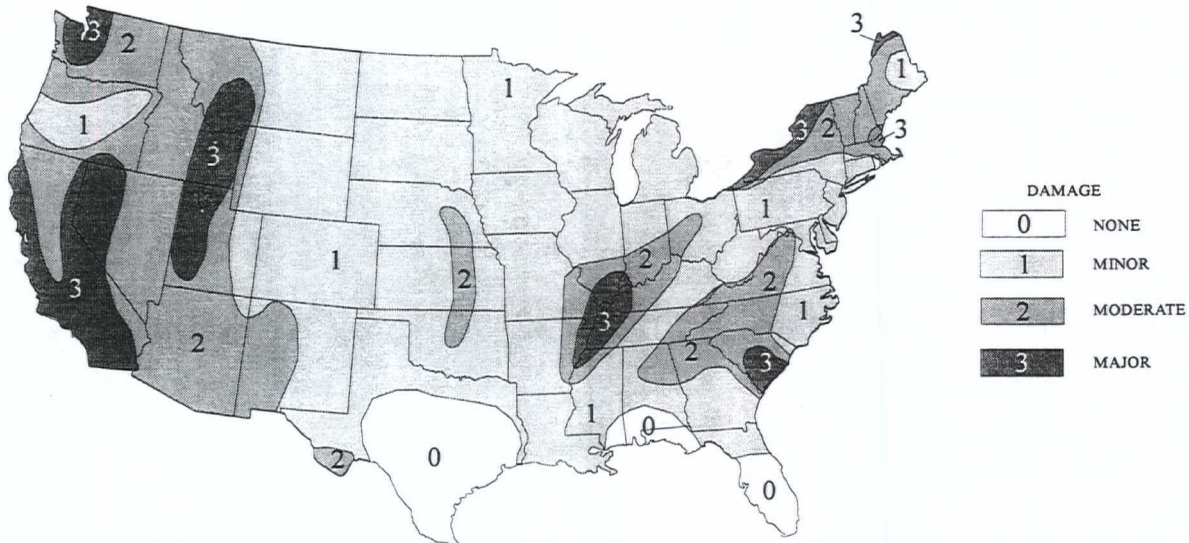
	R2W	R1W	R1E	R2E
T28N	None	None	None	Buck Lk. Finland Cr. Kincaid Cr. Nelson Cr.
T27N	None	None	Alder Cr. Fern Cr. Hudson Cr. Jump-off Cr.	Carpender Lk. Silver Cr.
T26N	None	None	Big Scandia Cr. Dogfish Cr. Jacques Cr. Johnson Cr. Tunnel Cr. Yount Cr.	Thompson Cr.
T25N	Boyce Cr.	Anderson Cr. Johnson Cr. Seabeck Cr.	Barker Cr., Brownsville Cr. Clear Cr., Crouch Cr. Crystall Cr., Island Lk. Knapp Cr., Koch Cr. Madison Cr., Mosher Cr. Steele Cr. Wood Cr.	Port Madison Cr.
T24N	Nelita Cr. Stavis Bay Cr. Thomas Cr.	Big Beef Cr. Gold Cr., Mission Cr. Mission Lk., Panther Lk. Tiger Lk. Tin Mine Lk. Tuhuyeh Cr. Union R. Wild Cat Lk.	Alexander Lk. Baily Cr. Black Jack Cr. Canyon Cr., Chico Cr. Dickerson Cr. Gorst Cr. Kitsap Cr., Kitsap Lk. Korb Cr. Wild Cat Cr.	Beaver Cr. Ehetai Spring Salmonberry Cr. Sullivan Cr.

Figure 3-12 is based on a computer listing of recorded water rights compiled by the Washington State Department of Ecology, Northwest Regional Office, dated 4 May 1995.

3.3.3.8 Seismology

Seismic risk maps published by the U. S. Coast and Geodetic Survey place Kitsap County and Subase Bangor in risk zone 3, indicating an expectancy of major destructive earthquakes. There have been approximately 200 earthquakes since 1840, but there is no known surface faulting. The most recent earthquakes of high magnitude in the region were near Olympia in 1949 (7.1 on the Richter scale) and near Seattle in 1965 (6.5 on the Richter scale). Two known fault traces have been identified in the county: the Kingston-Bothell trace in the northern portion of the county and the Seattle-Bremerton trace located a few miles north of Bremerton.

Figure 3-13
Seismic Risk Map for Conterminous U.S.



The map divides the U. S. into four zones: Zone 0, areas with no reasonable expectancy of earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, where major destructive earthquakes may occur.

Reference: Robert J. Foster, "Physical Geology," Charles E. Merrill Publishing Company, Second Edition, 1975

3.3.4 Climatology (References 2 and 3)

Because of its proximity to the Pacific Ocean and the influences of Puget Sound, the Kitsap Peninsula has a maritime climate, with generally cool, dry summers and mild, wet winters. Winds from the south and southwest generally bring rain, whereas winds from the north and northwest bring clear weather. Occasionally during winter, cold air flowing south from Canada brings subfreezing temperatures.

The average summer temperature is between 70° and 80°F during the day and 50° to 60°F at night. Temperatures during winter range from 40° to 50°F during the day and 30° to 40°F at night. Temperatures below 0°F or above 100°F seldom occur.

The Olympic Mountains to the west form a barrier against cyclonic storms. Moving eastward under the prevailing influences of western winds and storm centers, the warm moisture-laden winds from the Pacific Ocean are cooled by their ascent of the western slopes of the Olympic mountains and subsequently release heavy rainfall. Winds entering through valleys to the south carry moisture into the Puget Sound Basin and deposit precipitation in decreasing amounts as they move eastward toward the Cascade Mountains.

Subase Bangor, which is located in the northern part of the Kitsap Peninsula, is situated in the rain shadow of the Olympic Mountains and thus receives considerably less rainfall than the southern portion of the peninsula. Subase Bangor receives approximately 47 inches of precipitation annually, according to the 40-year mean from the National Oceanic Atmospheric Administration (NOAA), Bremerton station. Total annual snowfall is approximately 16 inches.

The area's prevailing winds are generally from the south or south-southwest with the exception of September, at which time the wind is generally from the north. During the winter season, high winds attain velocities ranging from 25 to 45 miles an hour. In the summer, the average wind velocity is lower and the number of windy days also decreases.

Five to eight days a month are clear or partly cloudy in the winter. In the summer, clear or cloudy days increase to about 20 per month. Fog occurs an average of 10 percent of the time, but is as high as 20 percent in October and November. Relative humidity ranges from 75 to 85 percent during the day and up to 85 percent at night.

According to the Federal Emergency Management Agency (FEMA), lands at or above an elevation of 10 feet above mean sea level are considered to be above the 100-year flood plain. Except for the Hood Canal beach and low lying areas adjacent to streams where they enter Hood Canal, all Subase Bangor elevations are greater than 10 feet above mean sea level.



4.0 Description of Operations

4.1 Background on Navy Organizational Activities

4.1.1 Naval Facilities Engineering Command (NAVFAC)

NAVFAC is responsible for taking the lead in negotiating Federal Facilities Agreements (FFAs) with EPA regional offices and states.

4.1.2 Navy Radiation Safety Committee (NRSC)

The NRSC, acting for the Chief of Naval Operations, manages the Navy's Master Materials License. The Navy has been delegated by the Nuclear Regulatory Commission (NRC), through the issuance of the Master Materials License, regulatory authority for the receipt, possession, distribution, use, transportation, transfer, and disposal of specified radioactive material at Navy and Marine Corps activities. The NRSC has been established to provide administrative control of all radioactive material used in the Navy and Marine Corps except for nuclear propulsion reactors and associated radioactivity, nuclear weapons, and certain components of weapons delivery systems. Navy Radioactive Material Permits (NRMPs, described in Section 4.4.1) are used to maintain this control. For Subase Bangor, the Radiological Affairs Support Office (see Section 4.1.6) is the designated technical support center for the NRSC.

4.1.3 Naval Sea Systems Command (NAVSEA)

NAVSEA is responsible for the radiological controls associated with non-weapons industrial radiography at Subase Bangor and other NRMP applications such as gas chromatographs and gauges that use radiation sources.

4.1.4 Bureau of Medicine and Surgery (BUMED)

BUMED is responsible for the radiological controls associated with radiation, occupational, and environmental health concerns of personnel involved with Naval operations at Subase Bangor. There are no nuclear medicine operations at Subase Bangor. Nuclear medicine operations are provided by the Naval Regional Medical Center in Bremerton.

4.1.5 Radiological Affairs Support Program (RASP)

The RASP is the vehicle used by NAVSEA to discharge its responsibility for radiological controls for applicable sources of ionizing radiation. The RASP applies to all ionizing radiation sources including NRC-licensed radioactive material, (non-NRC-licensed) naturally-occurring radioactive material (NORM) and accelerator-produced radioactive material (NARM, which includes NORM), radioactive waste, and machine sources such as x-ray machines, particle accelerators, electron microscopes, laboratory analytical devices, and all other equipment capable of producing ionizing radiation. Excluded are radioactive sources used for medical treatment or diagnosis, radioactivity associated with the NNPP, and radioactivity associated with nuclear weapons.

4.1.6 Radiological Affairs Support Office (RASO)

RASO provides technical support on behalf of NAVSEA to the NRSC, via the RASP, to include radiological assistance, program review, coordination of NRMPs, radiation safety training, and inspection of radiation safety programs.

4.2 General Radioactive Material (G-RAM)

Subase Bangor, along with its tenant commands, provides: intermediate level maintenance, alterations, repairs and testing on Naval submarines; homeporting of submarines and their crews; and training for submarine personnel.

General radioactive materials were common in shipboard equipment (e.g., radioluminescent dials, until recently) and in equipment used at support facilities (e.g., thoriated welding rods, continuing to the present). The use of radiographic and calibration sources has been essential to the industrial maintenance and repair operations at Subase Bangor. Although G-RAM consists mainly of sealed or encapsulated sources, radioactivity in other forms are (or have been) used at Subase Bangor.

Examples of G-RAM sources in use at Subase Bangor:

- Encapsulated iridium-192 radiography sources
- Sealed radiation detection instrument calibration and reference sources
- Sources contained in electron tubes
- Sealed or contained sources in various industrial and consumer products such as self-luminous signs and smoke detectors
- Sealed sources used in analytical equipment

4.3 Type of Activities

The primary activity involving G-RAM at Subase Bangor is industrial radiography. All work involving radioactive material is performed by persons specifically trained in accordance with the provisions of the respective Navy Radioactive Materials Permit (NRMP). NRMPs are discussed in detail in Section 4.4.1.

Activities involving G-RAM not controlled by a site-specific NRMP include radioactive commodities stocked/distributed by the Naval Supply system operating under an NRMP equivalent to an NRC general license for distribution or commodities license for exempt quantities. These commodities are controlled under Navy procedures, and include items containing radioactive material such as electron tubes, self-luminous devices, and sealed sources in certain analytical equipment.

4.4 Control of Radioactivity

A major objective in the performance of work involving any of the G-RAM described in this report is avoiding the potential for releases of low-level radioactivity into the environment. From the beginning of such work at Subase Bangor, even though sealed sources have been primarily involved, radiological work has been performed under strict controls to preclude the spread of contamination. An example is the periodic surveying of sealed sources to determine whether radioactivity remains contained within the source housing. This work has always been performed under controls at least as stringent as those imposed on radioactive material licensees by Title 10 of the Code of Federal Regulations (10 CFR Parts 19, 20, 21, 30, 31, 34, 35, and 71).

4.4.1 Licensed Radioactive Material

Under the provisions of 10 CFR, the Nuclear Regulatory Commission (NRC) has issued a Master Materials License to the Department of the Navy to control the receipt, acquisition, possession, use, transfer, and disposal of NRC licensed radioactive material. The Navy Radiation Safety Committee (NRSC) exercises regulatory authority over individual users, whose former NRC licenses were replaced with Navy Radioactive Materials Permits (NRMPs) in 1987. The NRSC assigns responsibilities to control the use of NRC licensed radioactive material as well as naturally occurring (NORM) and accelerator-produced radioactive material (NARM). NRC retains oversight for the Navy Radiation Safety Committee management of the master license.

The Navy Master Materials License does not apply to radioactive material transferred from the Department of Energy to the Department of Defense in accordance with Section 91B of the Atomic Energy Act of 1954 (e.g., Pu-Be calibration sources; such items are controlled as G-RAM), and it does not apply to radioactive material associated with the Naval Nuclear Propulsion Program.

The Subase has four currently active site-specific NRMPs and three inactive NCR licenses which were terminated in 1987. The radioactive sources for the terminated licenses were either transferred or shipped for disposal, and the facilities appropriately surveyed prior to their being released for unrestricted use. Table 4-1 (Current/Former Site-Specific Navy Radioactive Material Permits for Radioactive Material Held at Tenant Commands of Subase Bangor) details the four active NRMPs and three terminated NRC licenses. Table 4-1 does not include NRMPs issued by the NRC for Navy-wide use of certain radioactive material such as liquid and gaseous tritium calibration sources and sealed sources contained within specified analytical equipment; radiation detection instruments and calibrators; and self-luminous gauges and other equipment.

Table 4-1

**Current/Former Site-Specific Navy Radioactive Material Permits
for Radioactive Material Held at Tenant Commands
of Subase Bangor**

Navy Radioactive Material Permit/ former NRC License	Command	Purpose	Status
08-00030 T1NP/ 08-19268-01	Strategic Weapons Facility, Pacific	Maximum 40 mCi of nickel-63. Electroplated sources in electron tubes used in the firing component of the TRIDENT Destruction Initiation Unit.	Active
46-68438-A1NP/ 46-19259-01	TRIDENT Refit Facility	1. Maximum 100 Ci per source of iridium-192. Industrial radiography. 2. Maximum 999 kilograms of uranium shielding material. Industrial radiography.	Active
46-00253-A1NP/ 46-09611-01	Weapons Quality Engineering Center	Maximum 1,300 Ci per source of cobalt-60. Industrial radiography.	Active
46-00253-B1NP/ 46-09611-03	Naval Undersea Warfare Engineering Station	40 Ci of krypton-85 gas. "Radioflo" Leak Detector unit. Unit not in use. To be recycled.	Active
None/ 46-19259-02	TRIDENT Refit Facility	Maximum 15 mCi per source of nickel- 63. Gas chromatography foil sources.	Inactive
None/ 46-19259-01	TRIDENT Refit Facility	Maximum 10 Ci per source of cobalt- 60. Industrial radiography.	Inactive
None/ STB-930	Strategic Weapons Facility, Pacific	Maximum 250 pounds of an alloy of magnesium/thorium (3% thorium).	Inactive

4.4.2 Current G-RAM Controls

The Navy Radiation Safety Committee exercises headquarters level administrative control over G-RAM held under the provisions of NRMPs. The immediate controls over NRMP sources at Subase Bangor are provided by the respective commands. Technical oversight is provided by the Naval Sea Systems Command Detachment, Radiological Affairs Support Office (RASO).

All of the base NRMPs require adherence to 10 CFR Parts 19, 20, 21, and 30. Additional requirements are based on the scope of the specific permit (e.g., the industrial radiography NRMP requires adherence to 10 CFR Parts 34 and 71). Each command in possession of permitted sources is required to establish a radiological protection program and assign a qualified Radiation Safety Officer (RSO) to establish, implement, and maintain such a program. Each RSO is qualified in accordance with the pertinent 10 CFR requirements and exercises independent authority over G-RAM used within the respective command. Typical NRMP control requirements include: radiological surveys of radioactive material work and storage areas; leak tests of sealed sources; safety inspections; and audits of the radiological protection program.

G-RAM not addressed by site-specific NRMPs is also controlled at each command. Examples of such G-RAM include: thoriated welding rods; specified compasses and depth gauges; check sources attached to or incorporated in certain radiation detection instruments and analytical equipment; radioactive material incorporated in certain ionization or luminescent devices; and radioactive material incorporated in certain electron tubes and electronic devices. Periodic audits of such G-RAM are conducted; these audits continue to verify that appropriate custody, storage, fire protection, marking, transfer, and disposal procedures remain in effect.

4.4.3 Historical G-RAM Controls

Requirements for the control of G-RAM have always been consistent with pertinent federal regulations and with recommendations of national scientific committees. Requirements for the control of any G-RAM at Subase Bangor, even before passage of the 1954 Atomic Energy Act, were based on recommendations of the National Committee on Radiation Protection and Measurements (NCRP, founded in 1931, chartered by Congress and renamed in 1964 to the National Council on Radiation Protection and Measurements).

The Navy's radiological safety regulations, as revised in 1951 by the Bureau of Medicine and Surgery, implemented several recommendations of the NCRP (published at that time as National Bureau of Standards Handbooks) for specified radioactive material hazards including: NCRP Report No. 4, Radium Protection, 1938 (NBS Handbook 23, superseded by a series of NCRP reports); NCRP Report No. 5, Safe handling of Radioactive Luminous Compounds, 1941 (NBS Handbook 27, out of print); NCRP Report No. 6, Medical X-Ray Protection Up to Two Million Volts, 1949 (NBS Handbook 41, superseded by a series of NCRP reports); and NCRP Report No. 7, Safe Handling of Radioactive Isotopes, 1949 (NBS Handbook 42, superseded in 1964 by NCRP Report No. 30).

Navy requirements have continued to be updated in accordance with updates to national scientific committee recommendations and federal regulations (e.g., 10 CFR, created pursuant to the 1954 Atomic Energy Act). In 1963, the Navy began a series of programs to remove all non-mission essential equipment containing radioluminescent (e.g., radium) material, and replace such mission essential equipment with equipment containing non-radioluminescent or lower energy radioluminescent substitutes where possible.

Historical documentation is sparse regarding early uses of G-RAM which was not required to be licensed (e. g., radium) or was used before licensing was instituted. The earliest documented use of licensed G-RAM at Subase Bangor was for industrial radiography. In 1965 Puget Sound Naval Shipyard was performing leak tests of strontium-90 sources associated with radiography operations at the POLARIS Missile Facility, Pacific (POMFPAC), U.S. Naval Ammunition Depot (NAD), Bangor (Subase Bangor). A Puget Sound Naval Shipyard log book for the period October 1964 through December 1979 documents coordination between PSNS and Subase Bangor on G-RAM issues (i.e., radiation detection instrument calibration, radiation shielding, leak tests of sources, radioactive waste disposal, personnel dosimetry, and contamination control practices).

The AEC was reorganized in 1974, at which time the licenses were placed under the cognizance of the newly formed U. S. Nuclear Regulatory Commission (NRC). In 1987, NRC licenses were converted to NRMPs under the Navy's Master Materials License.

4.5 Regulatory Oversight

NRMP radiological controls at Subase Bangor are overseen by RASO. RASO conducts periodic on-site audits of the Subase Bangor NRMPs.

RASO audits the radiography NRMP annually, and requires internal audits/inspections on a six month basis or as stated otherwise in the NRMP, the Radiological Affairs Support Program (RASP) regulations, or federal regulations. These audits examine all NRMP-related work practices, including radiological controls, worker training, quality control, and compliance with work procedures and headquarters requirements.

Similar on-site audits which include non-regulated G-RAM work practices are conducted at Subase Bangor each year by radiologically-trained personnel on the Type Commander (SUBLANT) staff.

Regulatory interface regarding mixed (radiological and hazardous) waste is addressed in Section 5.3.

5.0 Policies and Results

5.1 Policies and Records Related to Environmental Release of Radioactivity

The policy of the Navy is to minimize the amount of radioactivity released to the environment. This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated into the Environmental Protection Agency in 1970), U.S. Nuclear Regulatory Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection, International Atomic Energy Agency, and National Academy of Sciences-National Research Council. To implement this policy of minimizing releases, the Navy has issued standard instructions defining radioactive release limits and procedures to be used by medical and non-medical Navy Radioactive Material Permit (NRMP) users, respectively. NAVSEA has additionally issued standard instructions defining procedures to be used in controlling that G-RAM which is not regulated by a specific NRMP. Current and historical G-RAM controls are described in Section 4.4.

5.1.1 Liquids

There are no liquid G-RAM items in use at Subase Bangor.

5.1.2 Gases

No work involving G-RAM at Subase Bangor (e.g., radiography) is required by 10CFR to use filtered and/or monitored exhaust ventilation.

Krypton-85 gas is contained within check sources used for instrument calibration and vacuum tubes used for electronic operations. This gas is inert and is encapsulated to prevent its release.

Perhaps the likeliest potential for airborne release of non-NRMP controlled sources involves grinding on thoriated welding rods. Any such work is controlled by Navy procedure to isolate grinding areas, provide exhaust ventilation, use wet belt machines to contain dust, clean grinding areas after use by vacuum cleaning or wiping, and to dispose of grinding dust, chips, and cleaning rags (as normal waste materials) as they are generated. Thorium-232 (a naturally-occurring radionuclide) is contained in various manufactured items such as incandescent gas mantles, welding rods, lenses, and aircraft engine parts. Manufactured items exempted from licensing requirements in 10 CFR 40.13 (such as thorium in welding rods) or authorized by a general license in 10 CFR 40.22 do not require an NRMP.

5.1.3 Solids

Solid G-RAM items in use at Subase Bangor include uranium shielding material and encapsulated sources containing iridium-192, cobalt-60 or, nickle-63. Any waste disposal of any of these items would have been performed in accordance with applicable provisions of 10 CFR.

In the late 1950's the Navy initiated actions to remove and replace non-operationally-essential luminescent material containing radium-226. The removed radium was to be disposed of as radioactive waste off-site at a licensed radioactive waste disposal site. This action was essentially complete by the mid-1970's.

5.1.4 Reports of Inadvertent Releases

An extensive search for archive copies of reports of inadvertent releases was conducted. Documents were examined to identify any instances in which G-RAM was inadvertently released. Table 5-1 summarizes data obtained during these reviews. These reviews verified that the affected areas were surveyed and sampled as required by regulations, and that the areas were properly released from radiological controls. The release criteria have always been consistent with federal regulations pertinent to the particular material.

That no detectable G-RAM radioactivity has accumulated in harbor water, harbor sediment, or edible aquatic species is confirmed by survey results reported in Section 6.

Table 5-1
**Summary of Reports of Potential
Radioactivity Releases to the Environment**

Date	Location	Volume	Activity
13 February 1974	NAD Disposal Area (outdoors area)		NA
Summary: Surveys performed by Puget Sound Naval Shipyard's Radiation Health Division personnel found a crate containing two radioactive range bearing instruments. Maximum gamma radiation reading on contact with the outside of the crate was 0.7 mR/hr. Maximum reading on the instruments was 30 mR/hr. No alpha contamination was detected.			
Response: Health Physics personnel concluded the source of radiation was internal to the instruments. Both instruments were disposed of as radioactive waste.			

Table 5-1, continued
**Summary of Reports of Potential
Radioactivity Releases to the Environment**

Date	Location	Volume	Activity
5 October 1984	Gauge Calibration Laboratory, TRIDENT Refit Facility Building 7000	NA	0.081 μ Ci radium-226
<p>Summary: Three gauges were worked on without radiological controls. During the second day of work, surveys were performed because a worker suspected the gauges contained radioluminescent material. Surveys detected alpha contamination up to 0.021 μCi. Radioisotopic analysis identified the contamination as radium-226. Two personnel had minor skin contamination: (1) right thumb, 150 cpm, alpha (2) hands, 200 cpm, alpha. A third person's clothes were contaminated. Contamination was spread within the lab. Air samples did not detect airborne radioactivity (less than 3×10^{-11} μCi/ml).</p> <p>Response: Work was stopped and the lab secured. The personnel were decontaminated. A high efficiency particulate air filtered exhaust ventilation system was installed for the decontamination of the lab. The highest level of loose surface contamination detected was 0.081 μCi, radium-226, in a tool box. The gauges had a beta-gamma dose rate of 4mR/hr. Lab decontamination was completed on 12 October 1984. Surfaces were decontaminated to background levels: zero ccmp/100 cm², alpha, and less than or equal to 40 cpm/100 cm², beta-gamma. Radon breath analysis was used to test all potentially exposed personnel (9 total) for internal contamination. The personnel with skin or clothing contamination were also whole-body monitored for internal contamination. No internal contamination was detected. Decontamination generated 7.3 cubic feet of solid radioactive waste. The waste was transferred to Puget Sound Naval Shipyard for disposal.</p>			

Date	Location	Volume	Activity
6 July 1988	Building 5003 Weapons Quality Engineering Center	NA	0.007 μ Ci cobalt-60
<p>Summary: Semi-annual wipe test of the 1,100 Ci cobalt-60 industrial radiography camera (U.S. Nuclear Corporation, Model BCOK-3) detected 0.0051 and 0.007 μCi. 10 CFR 34 defines a source as leaking if its wipe test detects 0.005μCi or more. Radioisotopic analysis verified the contamination was cobalt-60.</p> <p>Response: Follow-up wipe tests were all less than 0.005μCi. Investigation concluded the source was not leaking but was externally contaminated by the manufacturer during a source change. The manufacturer was informed of the problem. All subsequent semi-annual wipes tests have been less than 0.005μCi.</p>			

Notes: NA - not available.

5.2 Low-Level Solid Radioactive Waste Disposal

5.2.1 NRMP-Controlled G-RAM

Radiographic operations do not generate low-level radioactive waste. Radiographic sources have always been returned to the vendor when the source is no longer of use. It is possible that sealed check sources determined to have no more useful value could, in the future, be designated for ultimate disposal as low-level solid radioactive waste.

5.2.2 Non-Regulated G-RAM

Although the current record is clear that a common commercial item identified as containing general radioactive material (e. g., smoke detector, electron tube) would not be disposed of in the soil at Subase Bangor, historical documentation proving the prohibition of such disposal in the past has not been identified. No definitive statement can be made as to whether such material (e.g., radioluminescent dials) was ever disposed of in the soil.

5.3 Mixed Waste

G-RAM mixed waste (waste which is both hazardous and contaminated with low level radioactivity) has not been generated at Subase Bangor. The nature of the work performed at Subase Bangor makes it unlikely that any G-RAM mixed waste would be produced, but it is possible that the base could produce small quantities of such waste in the future.

Mixed waste generated by Subase Bangor would be handled by Puget Sound Naval Shipyard. Treatment of mixed waste would occur as specified in the Puget Sound Naval Shipyard Site Treatment Plan, in accordance with a consent order issued by the Washington State Department of Ecology in October 1995. Any such waste would be shipped elsewhere for storage or treatment.

5.4 Release of Facilities and Equipment Previously Used for Radiological Work

Navy regulations require that activities engaged in NRMP-controlled work compile and maintain lists of facilities, areas, and equipment that have been used in support of radiological work. These regulations further require that extensive radiological surveys be conducted when these radiological work or storage areas or equipment are being released from radiological controls. Any radioactivity detected by these surveys is removed and the area resurveyed or resampled until levels comparable to background are attained. Release criteria are consistent with applicable federal regulations.

Results of surveys are formally documented and archived. A written report describing the area, radiological history, surveys and sampling protocol, tabulated results, and conclusions is forwarded to the appropriate Naval headquarters organization.

No Subase Bangor facilities, areas, and equipment intentionally used in support of radiological work have been permanently released for unrestricted use. One area, the Gauge Calibration Laboratory in Building 7000, unintentionally used in support of radiological work (see Table 5-1) was surveyed and released from radiological controls.

5.5 Current Radiological Facilities

Other than active radiological work and storage areas, there are no areas within Subase Bangor where radioactivity exists above natural background levels. Current site-specific NRMP-controlled radiological work and storage areas are identified in Table 5-2.

Table 5-2
**Radiological Facilities Currently in Use
Controlled by a site-specific NRMP**

Facility	Radiological Use
CIF, Building 7201, High Bay	G-RAM Storage
Building 7000	Industrial Radiography
Building 5003 Weapons Quality Engineering Center	Industrial Radiography

Table 5-2 lists facilities controlled by a site-specific NRMP. Examples of facilities used for storage of G-RAM that is not controlled by a site-specific NRMP include: portions of Building 7000, used for in-transit storage in support of shipping and receiving radioactive material; and facilities used for storage of thoriated welding rods.

Navy regulations require the identification and control of buildings, structures, storage areas, or other facilities in which G-RAM is located unless the G-RAM consists of: transient sealed sources; sources with radioactivity levels under the exempt quantities specified in 10 CFR 30; sources which are generally licensed by the Nuclear Regulatory Commission or are exempt from licensing under 10 CFR 31 and are not installed in the building; unsealed medical sources with short half-lives; or common commercial items containing G-RAM such as dials, electron tubes, or smoke detectors.

6.0 Environmental Monitoring

Since July 1973, radiological environmental monitoring has been conducted at Subase Bangor by Puget Sound Naval Shipyard (PSNS). This monitoring consists of analyzing harbor sediment, water, and marine life samples for radioactivity associated with Naval nuclear propulsion plants, radiation monitoring around the perimeter of support facilities, and related monitoring. The scope and analysis methods of PSNS monitoring are sensitive enough to identify environmental radioactivity from various sources, such as that due to airborne nuclear tests in past years. Environmental samples are also checked at least annually by a U.S. Department of Energy laboratory to ensure analytical procedures are correct and standardized within the NNPP.

The NNPP environmental monitoring program does not include monitoring within the air, soil, or ground water pathways. The procedures discussed in prior sections to control radioactivity at the source during work, as substantiated by NESHAPS calculations, document that air releases are below the level of environmental significance. As discussed previously, shallow ground water in near shoreline areas drains directly to the harbor without impacting drinking water wells. For these reasons, the lack of direct air, soil, or ground water monitoring within the routine environmental monitoring program is acceptable.

The environmental monitoring program has emphasized the detection of cobalt-60, the predominant radionuclide associated with overhaul and repair of Naval nuclear powered ships. Although directed toward the NNPP, this monitoring is additionally indicative of the presence or absence of G-RAM, and pertinent results are included in this section.

6.1 Harbor Environmental Records

Harbor environmental monitoring data consisting of sediment, water, and marine life sample analysis data are applicable to the surface water pathway.

6.1.1 Sediment Sampling

In 1966, PSNS implemented a uniform Program environmental monitoring protocol. PSNS has taken quarterly harbor sediment samples at Subase Bangor since July of 1973. Sediment samples have been collected quarterly through the present.

Beginning in 1967, the NNPP has published an annual report of environmental monitoring and waste disposal throughout the entire Program. These reports have been made available to federal and state regulatory agencies, state governments, and the general public. Reference 5 is the latest in this series of reports.

Each of the annual reports contains sediment sampling data. Data for sediment sampling results reported annually by Puget Sound Naval Shipyard are included in Table 6-1.

Table 6-1
Gamma Radioactivity Concentration in Harbor Sediment Samples
Subase Bangor, 1973 - 1996

Year	Quarter	Number of Samples	Average Gross Gamma >0.1 MeV pCi/g	Range of Gross Gamma >0.1 MeV High/Low pCi/g
1973	3	35 (a)	0.8	1.3/0.4
	4	15	0.8	1.6/0.8
1974	1	15	0.8	1.1/0.5
	2	15	0.9	1.1/0.6
	3	15	0.8	1.1/0.4
	4	15	0.8	1.0/0.3
1975	1	15	0.8	1.0/0.4
	2	15	0.8	1.0/0.5
	3	15	0.8	1.1/0.4
	4	15	0.6	0.9/0.3
1976	1	15	0.7	1.1/<0.2
	2	15	0.7	1.0/0.2
	3	15	0.7	1.0/0.4
	4	15	0.7	0.9/<0.2
1977	1	15	0.7	1.1/0.4
	2	15	0.7	1.1/0.3
	3	15	0.7	1.0/0.3
	4	15	0.8	1.3/0.6
1978	1	15	0.8	1.0/0.5
	2	15	0.8	1.0/0.3
	3	15	0.7	0.9/0.4
	4	15	0.7	1.0/0.3
1979	1	15	0.8	1.1/0.4
	2	15	0.7	0.9/0.4
	3	15	0.7	1.0/0.4
	4	15	0.7	0.9/0.4
1980	1	30	0.7	1.2/0.3
	2	30	0.6	1.1/0.1
	3	29	0.6	0.9/0.1
	4	28	0.6	1.0/0.1
1981	1	30	0.7	1.3/0.2
	2	30	0.7	1.1/0.2
	3	30	0.7	1.0/0.2
	4	30	0.6	1.1/0.1
1982	1	30	0.6	1.0/0.1
	2	34	0.6	1.0/0.1
	3	34	0.6	1.1/0.1
	4	34	0.6	1.0/0.2
1983	1	34	0.8	1.4/0.1
	2	33	0.7	1.1/0.1
	3	33	0.6	1.0/0.1
	4	33	0.7	1.2/0.1
1984	1	33	0.6	1.2/0.1
	2	33	0.6	1.0/0.1
	3	33	0.6	1.1/0.2
	4	33	0.6	1.1/0.2
1985	1	33	0.8	1.2/0.2
	2	33	0.7	1.2/0.3
	3	33	0.8	1.1/0.2
	4	33	0.8	1.1/0.4

Table 6-1 (con't)
Gamma Radioactivity Concentration in Harbor Sediment Samples
Subase Bangor, 1973 - 1996

Year	Quarter	Number of Samples	Average Gross Gamma >0.1 MeV pCi/g	Range of Gross Gamma >0.1 MeV High/Low pCi/g
1986	1	33	0.8	1.9/0.1
	2	33	0.9	1.1/0.3
	3	33	0.8	1.2/0.3
	4	33	0.6	1.8/0.3
1987	1	33	1.0	2.9/0.5
	2	33	1.0	2.1/0.3
	3	31	0.9	1.1/0.8
	4	31	0.9	1.1/0.6
1988	1	31	0.7	2.2/0.1
	2	31	0.9	1.1/0.5
	3	31	0.9	2.3/0.6
	4	31	0.9	1.1/0.3
1989	1	31	0.9	2.1/0.7
	2	31	0.9	1.0/0.5
	3	31	0.8	1.1/0.6
	4	31	0.8	1.2/0.2
1990	1	31	0.8	1.1/0.2
	2	31	0.9	1.1/0.8
	3	31	0.9	1.1/0.6
	4	31	0.9	1.0/0.2
1991	1	31	0.9	1.1/0.7
	2	31	0.9	1.0/0.5
	3	31	0.9	1.1/0.7
	4	31	0.8	1.0/0.6
1992	1	31	0.9	1.0/0.8
	2	31	0.9	1.0/0.7
	3	31	0.9	1.1/0.7
	4	31	0.9	1.0/0.7
1993	1	31	1.0	1.2/0.8
	2	31	0.9	1.1/0.7
	3	31	0.9	1.1/0.8
	4	31	0.9	1.1/0.7
1994	1	31	0.9	1.1/0.8
	2	31	0.8	0.9/0.6
	3	31	0.9	1.0/0.7
	4	31	0.9	1.0/0.5
1995	1	31	NA (b)	NA
	2	31	NA	NA
	3	31	NA	NA
	4	31	NA	NA
1996	1	31	NA	NA
	2	31	NA	NA
	3	31	NA	NA
	4	31	NA	NA

Notes: (a) Thirty-five samples were taken during the initial survey performed between 17 July and 2 August 1973. The 35 samples included the 15 sample sites used in subsequent quarterly surveys and 20 one-time-only sample sites.
(b) NA - not available. Puget Sound Naval Shipyard procedures for analysis of environmental samples were changed in 1995 when detailed radionuclide analyses began being performed for all environmental samples. "Gross gamma, cobalt-60 equivalent activity" and "cobalt-60 energy range" data is no longer determined.

Figure 6-1
Environmental Monitoring Locations
Subase Bangor
1973 - 1979

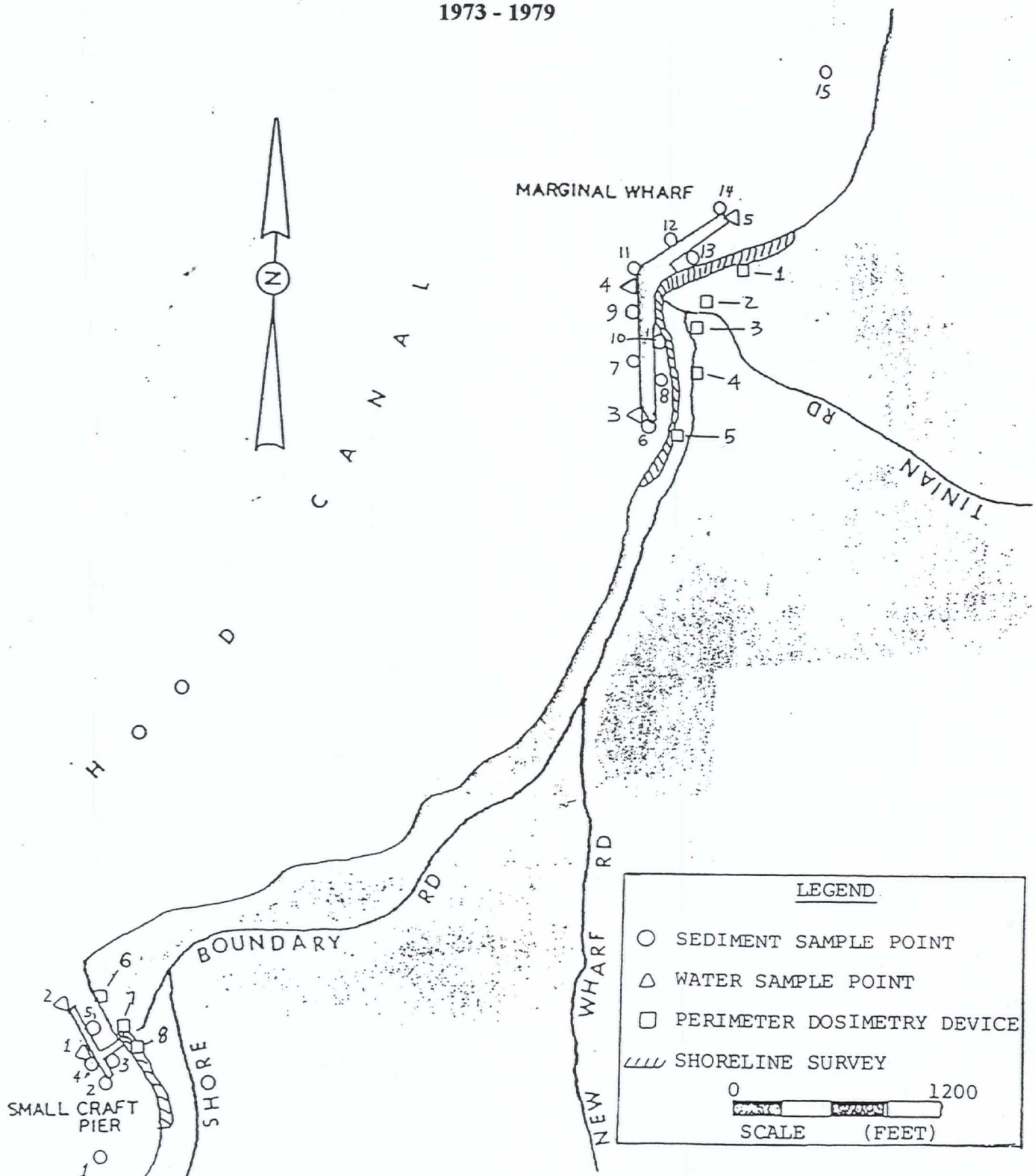


Figure 6-2
Environmental Monitoring Locations
Subbase Bangor
1980 - 1991

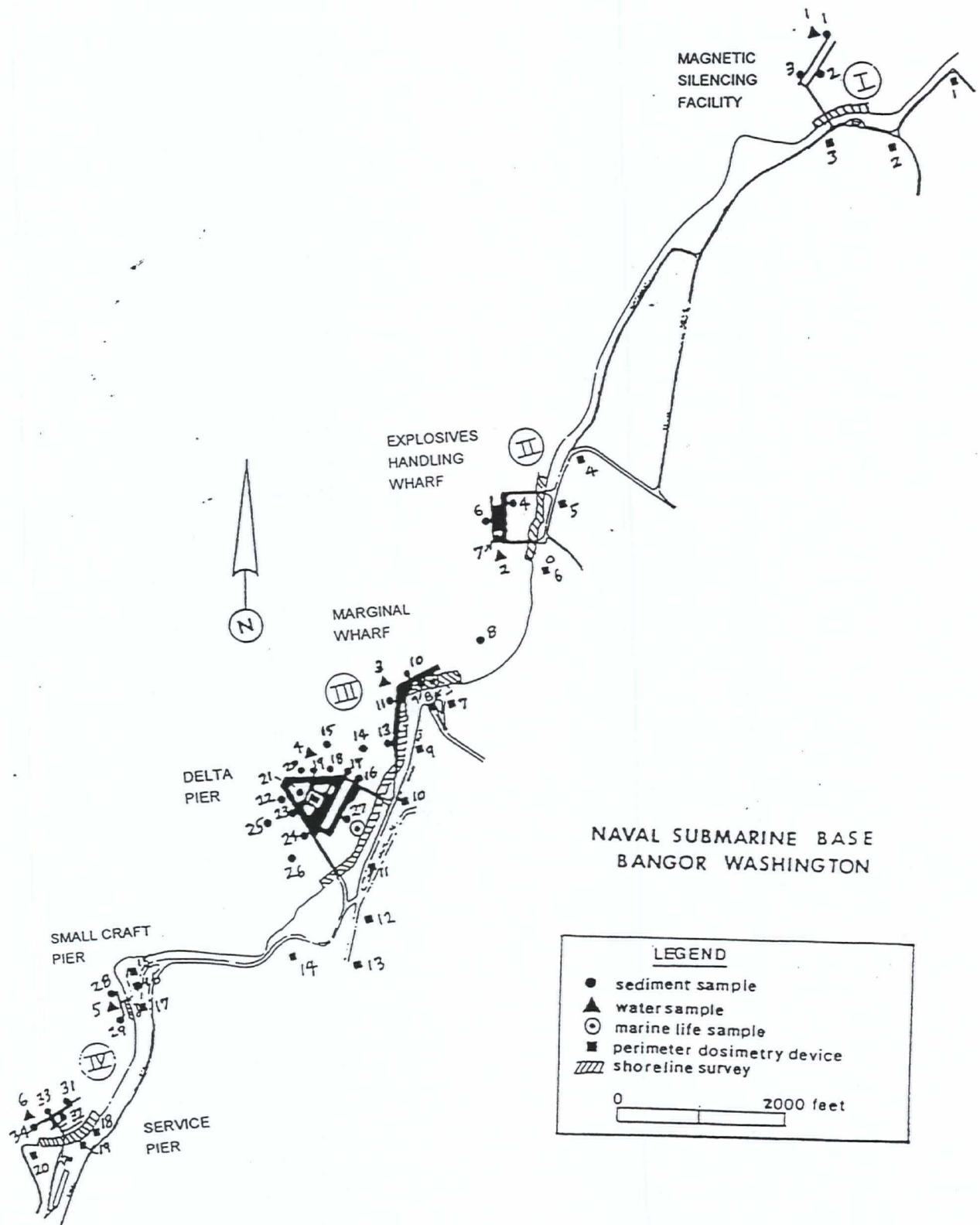
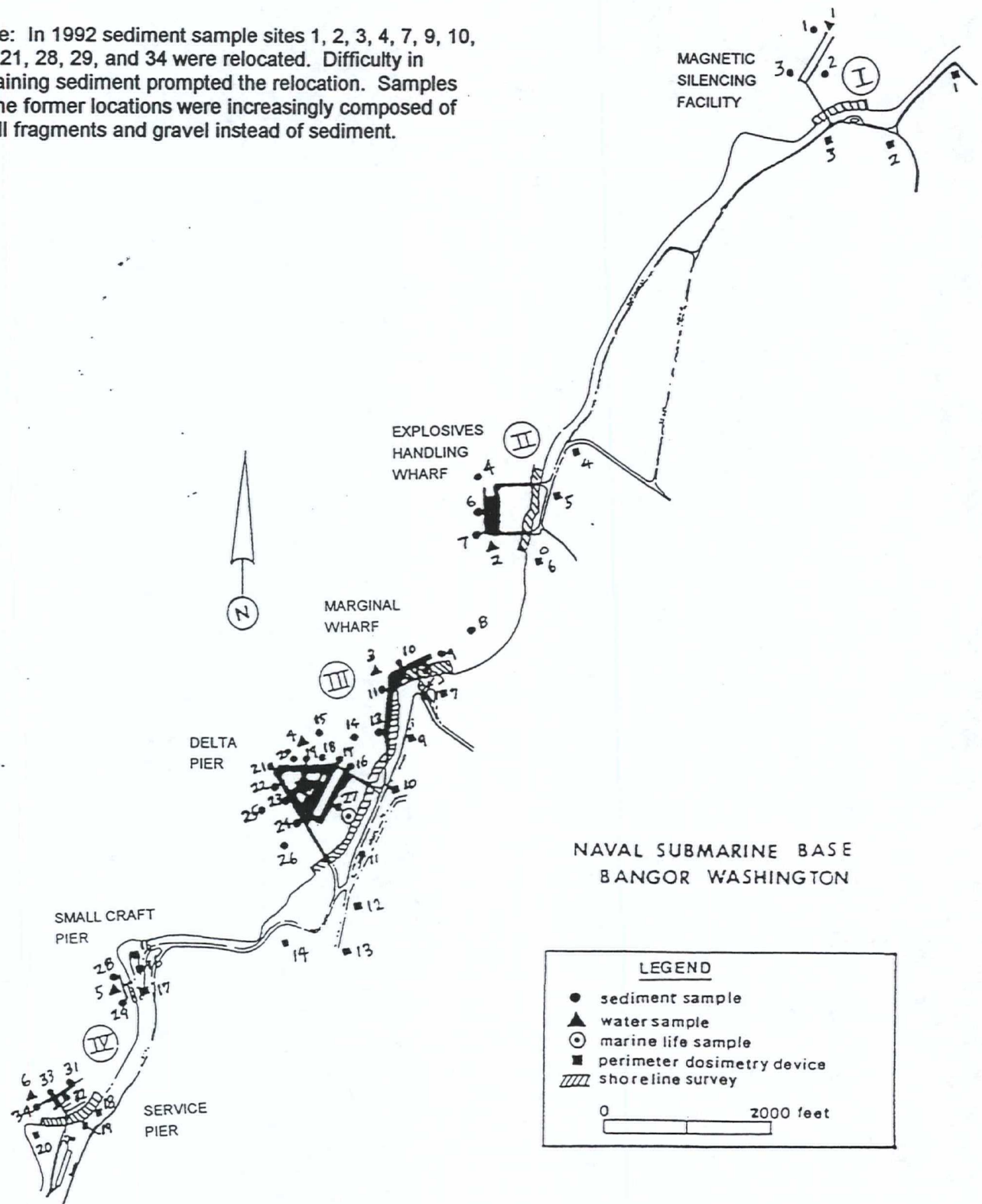


Figure 6-3
Environmental Monitoring Locations
Subase Bangor
1992 - 1996

Note: In 1992 sediment sample sites 1, 2, 3, 4, 7, 9, 10, 16, 21, 28, 29, and 34 were relocated. Difficulty in obtaining sediment prompted the relocation. Samples at the former locations were increasingly composed of shell fragments and gravel instead of sediment.



At present, 31 samples of harbor sediment are taken at Subase each quarter. Figures 6-1, 6-2, and 6-3 show the environmental monitoring locations for 1973 through 1979, 1980 through 1991, and 1992 through 1996, respectively. (The "small craft pier" on these figures, and the "Keyport/Bangor Dock" on Figure 3-4, are the same thing.) Sample locations are selected based on berthing locations of nuclear-powered ships and at points upstream and downstream of berths where tidal ebb and flood currents could deposit suspended radioactivity. Although sample locations have been selected based on NNPP operations, it can be seen from the figures that samples are collected across the length of the base's waterfront. If any gamma-emitting G-RAM attributable to base operations were present in Hood Canal, this monitoring program is sufficiently broad to assure detection.

A modified 6 inch square Birge-Ekman dredge is used to obtain a sample of the top 1/2 to 1-inch of the bottom sediment. This was selected since surficial sediments are more mobile and more accessible to marine life.

From 1973 through 1977, sediment sample material was transferred from the dredge to 1-quart cylindrical containers and analyzed using a sodium iodide scintillation detector and a multichannel analyzer. Starting in 1978, sample material was placed in Marinelli type containers to provide more efficient counting geometry and analyzed using a germanium detector.

PSNS has utilized cross-checks by independent laboratories to verify their sample analysis results. This program continues through the present, utilizing an independent Department of Energy (DOE) laboratory. In addition, beginning in 1981, a test sample having a known quantity of cobalt-60 radioactivity has been sent to PSNS by the laboratory annually for analysis. PSNS is not provided with quantitative data beforehand. Analysis results are forwarded to the DOE laboratory for comparison with the DOE laboratory counting results and the activity known during sample preparation. PSNS results have been consistent with DOE laboratory results. Tables 6-2 and 6-3 provide side-by-side comparisons of PSNS data and DOE laboratory data for routine PSNS samples, and for the DOE laboratory test samples, respectively.

Table 6-2
Comparison of PSNS and DOE Laboratory Data for Routine Sediment Samples (pCi/g)
(KAPL=Knolls Atomic Power Laboratory)

Gross Gamma (0.1 - 2.1 MeV)							
Year	No. of Samples	Average		Range			
		PSNS	KAPL	PSNS		KAPL	
				High	Low	High	Low
1996	10	NA	NA	NA	NA	NA	NA
1995	10	NA	NA	NA	NA	NA	NA
1994	21	0.68	0.714	1.10	0.31	1.13	0.358
1993	21	0.71	0.749	1.16	0.38	1.13	0.480
1992	21	0.62	0.650	0.97	0.33	0.997	0.323
1991	21	0.68	0.704	1.00	0.45	1.06	0.462
1990	21	0.63	0.635	1.10	0.27	1.10	0.285
1989	21	0.69	0.665	1.01	0.48	1.11	0.482
1988	21	0.67	0.650	1.23	0.25	1.21	0.207
1987	22	0.77	0.722	1.46	0.45	1.05	0.271
1986	22	0.67	0.659	1.50	0.30	1.42	0.251
1985	21	0.88	0.865	1.79	0.21	1.86	0.122
1984	21	0.7	0.7	3.06	0.08	2.89	0.104
1983	22	0.6	0.5	1.43	0.09	1.13	0.096
1982	20	0.9	0.9	3.89	0.10	4.11	0.114
1981	20	0.8	0.8	2.32	0.17	2.51	0.114
1980	20	0.8	0.8	3.53	0.07	3.65	0.085
1979	16	1.1	1.0	4.66	0.13	4.52	0.189
1978	16	1.2	1.2	5.96	0.28	6.00	0.21

Note: NA - not available. Only specific radionuclide analyses were performed beginning in 1995.

Table 6-3
Comparison of PSNS and DOE Laboratory Data for Test Samples

Simulated Sediment (pCi/g)													
Year	Actual Conc.		PSNS Measured		Actual Conc.		PSNS Measured		Other Isotopes				
	Co-60		Co-60		Cs-137		Cs-137		Isotope	Actual Conc.		PSNS Measured	
	Activity	+/-	Activity	+/-	Activity	+/-	Activity	+/-		Activity	+/-	Activity	+/-
1996	1.10	0.03	1.07	0.05	1.10	0.05	0.95	0.06					
1995	1.12	0.06	1.13	0.17	1.18	0.06	1.04	0.21					
1994	1.21	0.06	1.2	0.22	1.29	0.06	1.2	0.20					
1993	2.00	0.06	1.8	0.29	2.00	0.08	1.8	0.28					
1992	1.05	0.03	1.0	0.20	1.15	0.05	1.0	0.21					
1991	1.1	0.03	1.0	0.21	1.1	0.05	1.1	0.20					
1990	1.12	0.03	1.0	0.21	1.06	0.04	1.1	0.20					
1989	1.09	0.03	1.16	0.23	1.36	0.05	1.28	0.22					
1988	1.05	0.03	0.99	0.22	1.11	0.05	1.02	0.19	Co-57	0.49	0.01	0.50	0.08
1987	0.9	0.03	0.85	0.19	0.85	0.03	0.78	0.19					
1986	1.14	0.03	1.13	0.21	0.87	0.03	0.82	0.15	Cr-51	9.38	0.24	8.72	0.67
1985	2.16	0.06	2.22	0.35	0.6	0.02	0.46	0.16	Co-57	0.47	0.01	0.50	0.07
1984	1.97	0.05	1.86	0.30	0.92	0.03	0.97	0.18	Co-57	0.59	0.02	0.61	0.11
1983	0.7	0.02	0.84	0.19	1.56	0.06	1.58	0.23	Cs-134	1.44	0.04	1.64	0.25
1982	1.28	0.03	1.21	0.29	0.8	0.03	0.84	0.19	Cr-51	3.46	0.09	4.12	2.29
1981	0.79	0.03	0.80	0.20	1.16	0.03	1.48	0.23	Mn-54	0.99	0.05	0.92	0.21
1980	1.05	0.26	0.90	0.22	1.10	0.21	1.16	0.22	Co-57	1.96	0.15	2.10	0.18

During 1987 the U.S. Environmental Protection Agency (EPA) conducted independent assessments of radioactivity in the environs of Puget Sound Naval Shipyard and Subase Bangor. Measurements at Subase included radioactivity in four harbor water samples, nineteen bottom sediment samples, one sediment core sample, and nine marine life samples. Radioactivity measurements and assessments of the results are reported in Reference 6. EPA results are consistent with PSNS environmental monitoring program results. The Environmental Protection Agency survey concluded:

"A trace amount of Co-60 (0.04 ± 0.01 pCi/g) was detected in one sediment sample at PSNS. All other radioactivity detected in the eighty sediment samples is attributed to naturally occurring radionuclides or fallout from past nuclear weapons tests and the Chernobyl reactor accident in 1986.

"Water samples contained no detectable levels of radioactivity other than those occurring naturally.

"External gamma-ray measurements did not detect any increased radiation exposure to the public above natural background levels.

"Based on these surveys, current practices regarding nuclear-powered warship operations have resulted in no increases in radioactivity that would result in significant population exposure or contamination of the environment."

Prior to July 1973, the State of Washington Department of Social and Health Services (DSHS) was the only agency to routinely monitor Subase Bangor for radioactivity. Reference 7 summarizes annual DSHS sample results for Subase Bangor and other Naval facilities on Puget Sound from 1970 through June of 1975. Only naturally occurring radionuclides and those associated with fallout from past nuclear weapons tests were detected.

The data collected by the shipyard, the Environmental Protection Agency, and the State of Washington over the period 1970 through 1996 clearly support the conclusion that G-RAM activities at Subase Bangor: a) contribute a negligible increase to background radioactivity levels; and b) pose no hazard to the public, either directly or via the food chain, and pose no hazard to the ecological systems of the region.

6.1.2 Harbor Water Monitoring

The Naval Ordnance Systems Command Environmental Health Center performed an environmental radiation study of the Dabob Bay area in 1969. The study included 25 water samples collected near Subase Bangor's Small Craft Pier (K/B Dock). Water samples were analyzed for gross beta radioactivity. Reference 8 reports the results of the study. The conclusion of the study of the Dabob Bay area, including Subase Bangor, states:

"Analysis of this data does not reveal the presence of radioactive materials other than those which are normally present."

Beginning in July 1973 and continuing through the present, quarterly samples of water from Hood Canal have been collected and analyzed. Sampling locations are shown on Figures 6-1, 6-2, and 6-3.

Sample locations are selected based on areas where radioactive liquids could have been discharged and at upstream and downstream locations.

Between 1973 and 1977, six-liter samples were counted in shipyard-made Marinelli containers with a 3-inch by 3-inch sodium iodide scintillation detector and a multichannel analyzer. Since 1978, 500 ml samples have been placed in Marinelli counting containers and analyzed with a germanium high resolution spectroscopy system.

Since 1978, the counting procedure for water samples has been the same as for sediment samples. The quality control sample sent annually by the DOE laboratory serves to verify both sediment and water sample analysis results.

Two drinking water and two surface water samples were taken at Subase Bangor by the U. S. Environmental Protection Agency (EPA) in 1987 (Reference 6). The two surface water samples were collected near Delta Pier. EPA results are consistent with PSNS environmental monitoring program results.

No radioactivity attributable to Navy operations has been detected in any water sample taken at Subase bangor since the inception of the monitoring program. The only radionuclides that have occasionally been detected in these water samples are the naturally-occurring K-40, and series radionuclides of uranium and thorium. A review of both PSNS gamma counting results and the series of environmental monitoring reports published annually by the Naval Nuclear Propulsion Program reveals that no above-background levels of any radionuclides have ever been detected in harbor water samples. Quarterly data for each year is reported annually by PSNS. The water sample data are not tabulated in this report since they reflect over 20 years of less than minimum detectable activity concentration values for radioactivity attributable to Navy operations.

6.1.3 Marine Life Sampling

The Naval Ordnance Systems Command Environmental Health Center performed an environmental radiation study of the Dabob Bay area in 1969. A total of fourteen marine life samples were collected along the shore of Hood Canal and analyzed for gross beta radioactivity. Reference 8 reports the results of the study. The conclusion of the study of the Dabob Bay area, including Subase Bangor, states:

"Analysis of this data does not reveal the presence of radioactive materials other than those which are normally present."

On 31 July 1973, PSNS collected oysters from a section of the beach approximately 1200 feet south of Marginal Wharf. The oysters were shucked and the meat was combined into a sample that weighted 964 grams. Sample analysis indicated less than 0.15 pCi/g gross gamma radioactivity.

Beginning in 1977, Program activities conducting environmental monitoring were required to obtain marine life samples during July of each year. Samples include available species of marine plants, mollusks, and crustaceans from sample locations shown in Figure 6-1. Analysis data of marine life samples taken since 1978 are shown in Table 6-4 (the species of mollusk collected varies from year to year). The following species of marine life were collected and analyzed:

Scientific Name	Common Name
Marine Plant: Ulva	Green Sea Lettuce
Mollusk: Protothaca staminea Venerupis staminea Callithaca tenerrima Mytilus edulis Tresus nuttalla Clinocardium nuttalla Saxidomus giganteus	Littleneck Clam Thin-Shell Littleneck Edible Mussel Horse Clam Basket Cockle Butter Clam
Crustacean: Cancer productus Cancer magister	Red Rock Crab Dungeness Crab

Marine life samples were collected by the EPA in 1987 at six Subase Bangor sites. Radioactivity measurements and assessment of the results are reported in Reference 6. Other than naturally occurring radionuclides, only radioactive silver-110m was detected in two mollusk samples. The source of the silver-110m was not determined. The EPA concluded it may have been fallout from the Chernobyl reactor accident.

On the basis of the data shown in Table 6-6, the Naval Ordnance Systems Command Environmental Health Center survey reported in Reference 8, and the findings of the EPA survey reported in Reference 6, there has been no accumulation of radionuclides in marine organisms as a result of G-RAM work at Subase Bangor.

Table 6-4
Marine Life Monitoring Results
Subase Bangor

Year	Sample Type	Average Gross Gamma 0.1 - 2.1 MeV pCi/g	Range Gross Gamma 0.1 - 2.1 MeV pCi/g
1996	Crustacean	NA (a)	NA
	Mollusk	NA	NA
	Marine Plant	NA	NA
1995	Crustacean	NA	NA
	Mollusk	NA	NA
	Marine Plant	NA	NA
1994	Crustacean	0.12	0.12
	Mollusk	0.14	0.12 - 0.16
	Marine Plant	0.22	0.21 - 0.24
1993	Crustacean	0.15	0.11 - 0.19
	Mollusk	0.17	0.13 - 0.22
	Marine Plant	0.23	0.17 - 0.30
1992	Crustacean	0.11	0.11
	Mollusk	0.12	0.10 - 0.13
	Marine Plant	0.41	0.31 - 0.50
1991	Crustacean	0.06	0.05 - 0.06
	Mollusk	0.13	0.12 - 0.14
	Plant	0.16	0.09 - 0.25
1990	Crustacean	0.09	0.09
	Mollusk	0.75	0.11 - 1.4
	Marine Plant	0.12	0.06 - 0.17
1989	Crustacean	0.09	0.09
	Mollusk	0.12	0.10 - 0.14
	Marine Plant	0.17	0.15 - 0.18
1988	Crustacean	0.07	0.07
	Mollusk	0.08	0.08 - 0.09
	Marine Plant	0.15	0.09 - 0.20
1987	Crustacean	<0.08	<0.08
	Mollusk	0.16	0.15 - 0.16
	Marine Plant	0.24	0.21 - 0.26
1986	Crustacean	0.14	0.14
	Mollusk	0.16	0.16
	Marine Plant	0.29	0.29
1985	Crustacean	0.07	0.07
	Mollusk	0.11	0.11
	Marine Plant	0.28	0.28
1984	Mollusk	0.09	0.09
	Crustacean	0.11	0.11
	Marine Plant	0.25	0.25
1983	Crustacean	0.10	0.10
	Mollusk	0.14	0.14
	Marine Plant	0.29	0.29
1982	Crustacean	0.10	0.10
	Mollusk	0.07	0.07
	Marine Plant	0.18	0.18
1981	Crustacean	0.11	0.11
	Mollusk	0.17	0.17
	Marine Plant	0.36	0.36
1980	Crustacean	0.06	0.06
	Mollusk	0.08	0.08
	Marine Plant	0.24	0.24
1979	Crustacean	0.09	0.09
	Mollusk	0.15	0.15
	Marine Plant	0.34	0.34
1978	Crustacean	0.08	0.08
	Mollusk	0.19	0.19
	Marine Plant	0.35	0.35

Note: a. NA - not available. Only specific radionuclide analyses were performed beginning in 1995. Only naturally occurring radionuclides were identified in samples.

6.1.4 Core Sampling

No Hood Canal sediment core samples have been collected by PSNS.

The EPA collected one core sample in 1987. The sampling site was just south of Delta Pier. Reference 6 reported that all radionuclides identified in the sample were attributed to naturally occurring radionuclides or fallout. The radionuclide content of the core sample showed no significant differences with depth or in comparison to the surface sediment samples taken at the same site.

6.2 Dredging Records

Dredging is occasionally conducted at Subase Bangor to maintain the prescribed depth at piers and wharves. Since 1975, annual environmental monitoring reports prepared by PSNS have normally stated whether or not dredging has occurred, its location, and its volume. Additional sources of dredging information are Reference 2 (Final Remedial Investigation Report) and correspondence with Subase Bangor's Public Works Department. The following dredging has occurred at Subase Bangor:

- Dredging occurred in 1977 and 1978 during construction of Delta Pier. (Specifics not available.)
- In 1986 approximately 10,500 cubic meters were removed from an area south and east of the Small Craft Pier (K/B Dock). Spoils were disposed at Four Mile Rock in Elliot Bay.
- In 1987 approximately 2,700 cubic meters were removed from the caisson moorage area north and east of the drydock. Spoils were disposed upland on Subase Bangor in the area west of Archerfish Road and south of Runner Road.
- In 1994 approximately 3,560 cubic meters were removed from the caisson moorage area north and east of the drydock. The spoils were disposed in Puget Sound at the Port Gardener site south of Whidbey Island.

Neither PSNS nor Subase Bangor have sampled dredge spoils or dredge spoil disposal sites for radioactivity since sediment sampling data have not shown any radionuclides associated with the NNPP.

6.3 Perimeter Radiation Records

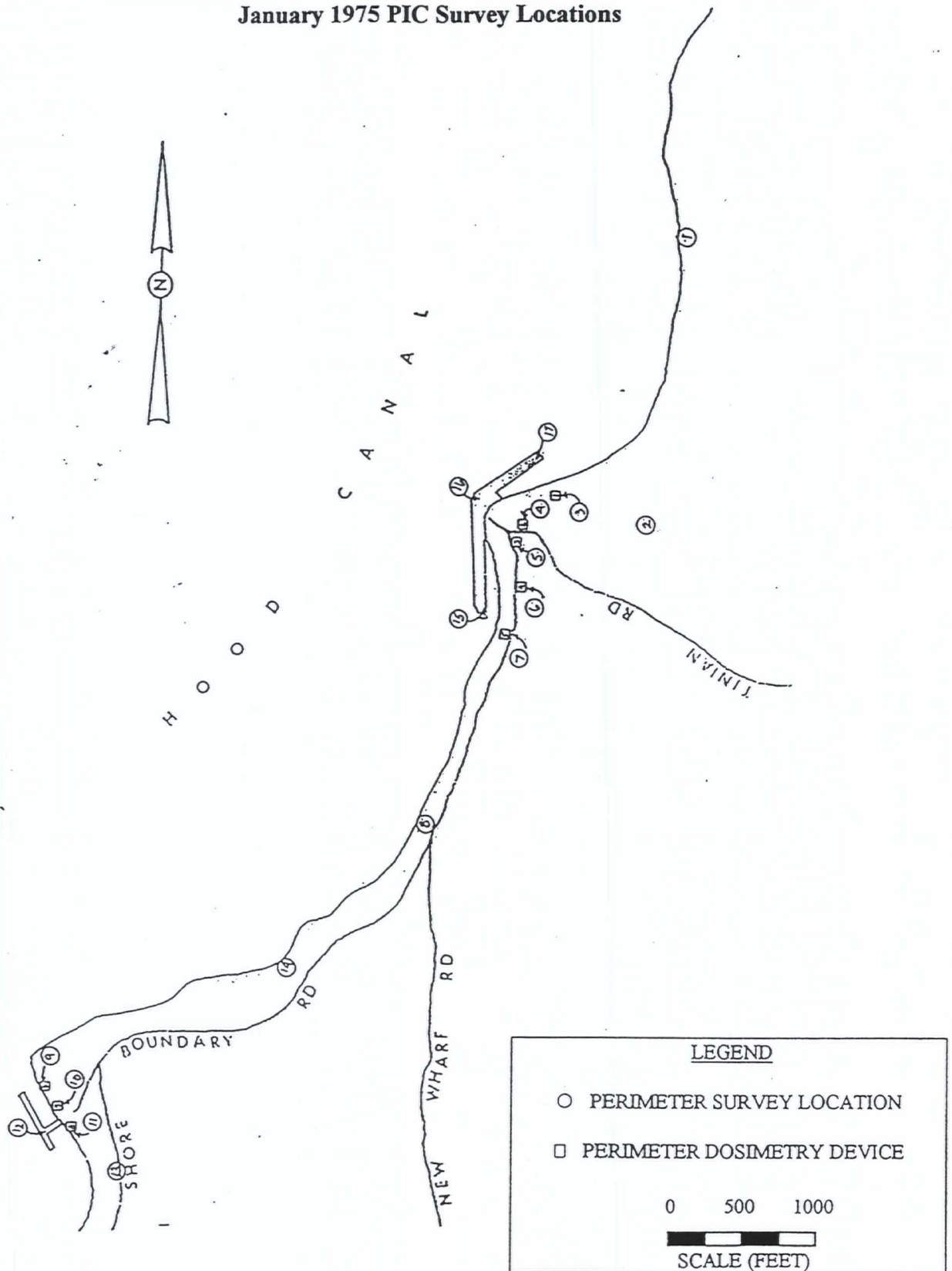
Beginning in the third and fourth quarters of 1973, beta-gamma film badges were posted outside of controlled radiation areas to ensure that unmonitored personnel within the Subase and the general public were not exposed to radiation levels above natural background. They were changed monthly. Film badges were replaced with thermoluminescent dosimeters (TLDs) in 1974. TLDs are replaced quarterly. Figures 6-1, 6-2, and 6-3 show the locations of posted perimeter dosimetry devices.

In January 1975 PSNS performed a special survey of seventeen locations at Subase Bangor with a Reuter-Stokes pressurized ion chamber (PIC). Shoreline readings ranged from 4.9 to 6.5 $\mu\text{R/hr}$ with an average of 5.9 $\mu\text{R/hr}$. Readings taken on piers ranged from 6.2 to 6.4 $\mu\text{R/hr}$ with an average of 6.2 $\mu\text{R/hr}$. Control readings taken over land ranged from 4.9 to 6.2 $\mu\text{R/hr}$ with an average of 5.7 $\mu\text{R/hr}$. Figure 6-4 shows the survey locations. In December 1978 PSNS performed a special survey of the eight environmental TLD locations at Subase Bangor with a Reuter-Stokes PIC. The readings ranged from 4.6 to 7.0 $\mu\text{R/hr}$ with an average of 5.8 $\mu\text{R/hr}$.

During August 1980 PSNS performed another special survey of Subase Bangor with a Reuter-Stokes pressurized ion chamber (PIC). Readings were taken at the 49 locations shown in Figure 6-5. The PIC readings ranged from 4.7 to 7.4 $\mu\text{R/hr}$ with an average of 6.4 $\mu\text{R/hr}$. The PIC survey locations included the 17 environmental TLD locations.

The special PIC surveys performed by PSNS provide additional evidence that the radiation levels at Subase Bangor's environmental monitoring locations are due to natural background radiation.

Figure 6-4
January 1975 PIC Survey Locations



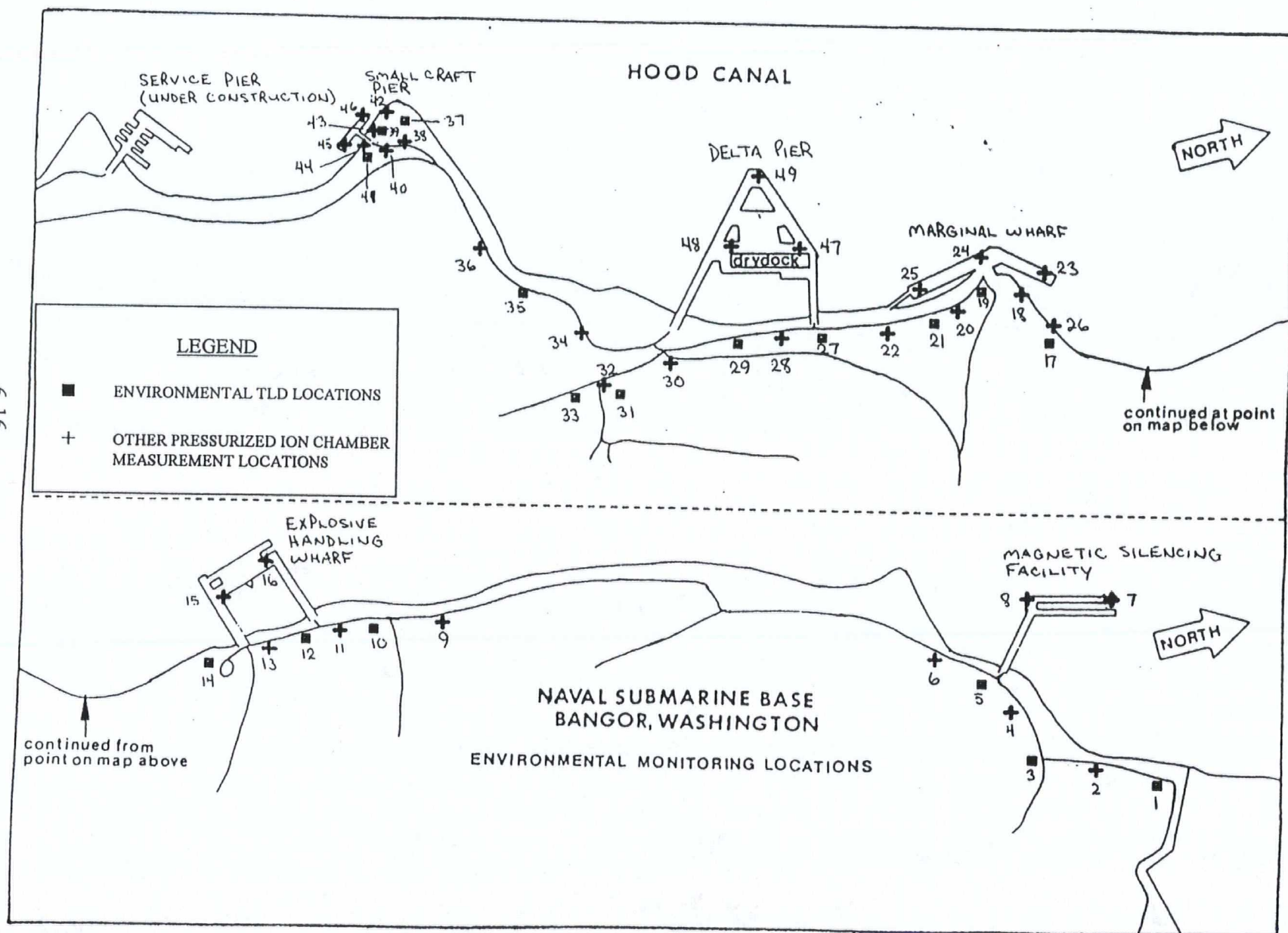


Figure 6-5
August 1980 PIC Survey

Beginning in 1978, clusters of five TLDs were posted at background locations, replacing the single TLD posted previously. Examples of background locations include: Naval Undersea Warfare Engineering Station (Keyport), Marine Corps Rifle Range (Camp Wesley Harris), and Naval Fuel Depot (Manchester). This method provided a better statistical basis for background determination and improved reliability.

Table 6-7 lists annual summary results of the perimeter monitoring program since 1974, when the use of TLDs was initiated. The results of the monitoring verify that radiation exposure to the general public is indistinguishable from natural background.

Table A-1 of Reference 9 lists the annual total body dose due to natural sources in the vicinity of Subase Bangor as approximately 87 mrem ($9.9 \mu\text{R/hr}$): 46 mrem is due to terrestrial sources of natural radioactivity and 41 mrem is due to cosmic radiation. Reference 9 is cited extensively by the National Council on Radiation Protection and Measurements (NCRP) as a continuing source of data for natural background radiation exposure estimates. This referenced estimate for natural background radiation exposure rate in the vicinity of Subase Bangor is consistent with data in Table 6-6, which is a tabulation of values reported in Reference 6, PSNS data, and Subase Bangor TLD fourth quarter data for 1994.

Table 6-5
Perimeter Radiation Monitoring
Subase Bangor
1974-1996

Year	Quarter	Exposure Rate Range mrem/qtr		Average Exposure Rate mrem/qtr	
		Background	Perimeter	Background	Perimeter
1974	1	13.7 - 16.9	13.1 - 14.7	15.3	13.8
	2	14.1 - 15.2	12.2 - 14.9	14.7	14.3
	3	15.3 - 16.9	14.1 - 16.9	16.2	15.4
	4	15.1 - 17.3	14.1 - 16.8	15.9	15.0
1975	1	15.3 - 16.6	14.1 - 15.3	15.8	14.7
	2	15.4 - 16.7	14.1 - 16.5	16.2	15.3
	3	15.4 - 17.1	14.1 - 16.3	16.2	15.3
	4	15.1 - 16.6	13.6 - 15.7	15.8	14.7
1976	1	14.9 - 16.7	13.7 - 16.0	15.8	14.9
	2	15.0 - 16.5	13.9 - 15.9	15.8	14.9
	3	15.2 - 16.8	13.4 - 16.0	16.2	15.0
	4	15.5 - 17.1	14.0 - 16.9	16.1	15.2
1977	1	14.6 - 16.2	13.5 - 15.8	15.4	14.6
	2	14.6 - 16.6	12.5 - 16.3	15.6	14.8
	3	15.3 - 17.6	14.0 - 16.2	16.6	15.4
	4	15.1 - 16.7	14.0 - 16.2	15.7	14.9
1978	1	15.5 - 17	13.9 - 16.8	16.4	15.2
	2	15.7 - 17	14.3 - 15.9	16.4	15.0
	3	15.5 - 17	14.7 - 16.7	16.4	15.4
	4	15.2 - 18	13.9 - 17.2	16.2	15.2
1979	1	15.0 - 17	14.1 - 16.5	16.0	15.3
	2	14.3 - 17	13.6 - 15.8	15.6	14.8
	3	15.0 - 18	14.2 - 16.7	16.3	15.4
	4	14.6 - 17	13.9 - 16.8	16.1	15.2
1980	1	15.3 - 16.6	14.4 - 17.3	15.9	15.6
	2	14.8 - 17.1	14.1 - 17.7	16.1	15.8
	3	14.9 - 17.4	14.4 - 17.2	16.2	16.2
	4	15.1 - 17.1	14.3 - 17.5	16.0	15.8
1981	1	15.7 - 17.6	14.6 - 18.0	16.7	16.3
	2	15.6 - 16.9	14.8 - 17.1	16.1	15.9
	3	15.8 - 17.6	14.6 - 18.0	16.7	16.3
	4	15.4 - 17.6	15.0 - 18.2	16.5	16.4
1982	1	15.6 - 17.4	14.9 - 16.9	16.4	16.1
	2	15.4 - 16.8	14.5 - 17.4	16.0	15.7
	3	16.0 - 17.5	14.6 - 17.6	16.7	16.3
	4	15.5 - 17.0	15.0 - 17.6	16.3	16.2
1983	1	15.3 - 17.5	14.7 - 18.1	16.3	16.1
	2	14.7 - 17.0	14.4 - 17.5	16.4	15.9
	3	15.1 - 17.0	14.4 - 17.3	16.2	15.9
	4	15.3 - 17.1	14.5 - 18.1	16.2	15.8

Table 6-5 (con't)
Perimeter Radiation Monitoring
Subase Bangor
1974-1996

Year	Quarter	Exposure Rate Range mrem/qtr		Average Exposure Rate mrem/qtr	
		Background	Perimeter	Background	Perimeter
1984	1	14.8 - 17.0	13.5 - 16.7	15.5	15.3
	2	15.8 - 17.4	14.4 - 17.3	16.6	16.2
	3	16.2 - 17.7	14.7 - 18.7	17.0	16.5
	4	16.1 - 18.4	16.1 - 19.0	17.1	17.2
1985	1	16.2 - 17.5	15.8 - 18.8	16.9	16.8
	2	15.8 - 17.3	14.8 - 17.6	16.6	16.3
	3	15.0 - 16.1	14.4 - 16.7	15.7	15.5
	4 (a)	17.3 - 18.6	16.1 - 19.4	18.0	18.0
1986	1	15.1 - 16.5	13.9 - 16.8	15.7	15.4
	2	15.9 - 17.6	15.0 - 18.9	16.8	16.5
	3	16.3 - 17.7	15.1 - 18.1	16.9	16.5
	4	16.2 - 18.2	15.4 - 17.5	17.1	16.5
1987	1	15.2 - 17.0	15.0 - 17.0	16.1	16.0
	2	15.6 - 17.2	15.4 - 18.0	16.5	16.7
	3	13.0 - 16.8	15.1 - 17.6	16.4	16.3
	4	16.1 - 17.8	15.2 - 18.3	17.2	17.0
1988	1	16.6 - 18.4	16.3 - 18.6	17.2	17.3
	2	13.1 - 17.9	15.6 - 19.2	16.2	17.1
	3	13.4 - 15.6	13.1 - 16.6	14.4	14.1
	4	13.7 - 15.6	11.5 - 16.2	14.6	14.5
1989	1	14.1 - 15.9	13.7 - 16.1	15.0	14.9
	2	14.2 - 16.8	13.2 - 16.7	15.4	15.0
	3	14.2 - 16.8	11.6 - 16.9	15.5	15.1
	4	14.5 - 16.2	13.7 - 17.4	15.5	15.4
1990	1	12.9 - 16.0	12.8 - 17.3	15.1	14.6
	2	14.4 - 16.4	13.8 - 17.4	15.5	15.3
	3	14.5 - 16.4	14.2 - 17.6	15.4	15.5
	4	15.0 - 16.5	14.0 - 17.5	15.8	15.7
1991	1	15.0 - 16.0	12.5 - 19.3	15.9	15.3
	2	12.9 - 16.3	12.9 - 17.8	14.8	15.0
	3	14.6 - 17.4	13.7 - 19.2	15.9	15.6
	4	15.6 - 18.1	14.1 - 18.1	16.5	16.0
1992	1	13.8 - 16.3	13.2 - 16.9	15.1	14.9
	2	12.9 - 17.8	11.9 - 16.7	14.8	14.2
	3	14.0 - 16.6	12.4 - 16.8	15.2	15.0
	4	13.9 - 16.3	13.3 - 18.4	15.1	15.0
1993	1	12.9 - 16.2	12.4 - 16.7	14.4	14.6
	2	13.5 - 16.7	12.5 - 15.7	14.7	14.7
	3	14.2 - 17.0	12.8 - 17.3	15.4	15.4
	4	14.0 - 16.6	13.8 - 17.6	15.1	15.1

Table 6-5 (con't)
Perimeter Radiation Monitoring
Subase Bangor
1974-1996

Year	Quarter	Exposure Rate Range mrem/qtr		Average Exposure Rate mrem/qtr	
		Background	Perimeter	Background	Perimeter
1994	1	13.4 - 15.8	12.8 - 17.3	14.9	14.9
	2	13.2 - 17.8	11.7 - 18.8	14.9	14.8
	3	11.7 - 16.6	12.0 - 18.0	15.0	14.8
	4	12.0 - 15.4	12.6 - 16.1	14.3	14.5
1995	1	14.5 - 16.2	13.4 - 17.4	15.4	15.2
	2	14.6 - 16.4	13.1 - 18.2	15.5	16.0
	3	14.7 - 16.6	13.3 - 16.9	15.5	14.9
	4	14.8 - 16.3	13.6 - 18.5	15.5	15.7
1996	1	14.7 - 16.1	13.2 - 17.9	15.4	15.5
	2	15.7 - 16.4	14.3 - 17.2	16.1	15.6
	3	16.0 - 18.1	14.7 - 17.4	16.9	16.6
	4	16.1 - 18.1	15.1 - 18.4	16.9	16.6

Note: (a) Fourth quarter 1985 values are for 14 weeks, instead of the normal 13 weeks.

Table 6-6
Perimeter Radiation Monitoring Comparison
Subase Bangor

Year	Survey	Ref.	Exposure Rate Range μR/hr	Average Exposure Rate μR/hr
1975	PSNS (PIC)	NA		
	Shoreline		4.9 - 6.5	5.9
	Piers		6.2 - 6.4	6.2
	Background Land		4.9 - 6.2	5.7
1978	PSNS (PIC) Shoreline	NA	4.6 - 7.0	5.8
1980	PSNS (PIC)	NA		
	Shoreline Piers		5.0 - 7.4 4.7 - 6.8	6.5 6.0
1987	EPA (PIC & portable scintillation)	16		
	Shoreline south of Delta Pier Shoreline north of Explosives Handling Wharf		8.0 - 9.0 7.0 - 10.0	8.5 8.5
1994 4th Quarter	Subase (TLDs) Shoreline	NA	5.8 - 7.4	6.6

Note: NA - not applicable

EPA concluded in Reference 6 that "External gamma-ray measurements did not detect any increased radiation exposure to the public above natural background levels." This conclusion applied to Subase Bangor as well as PSNS and is consistent with the Navy findings reported annually for the past 25 years in Reference 10 and successive reports through Reference 5.

The State of Washington Department of Health has measured ambient radiation levels near SUBASE Bangor with TLDs. State results are consistent with the results of PSNS's environmental monitoring program and are reported in the State's annual environmental monitoring reports. For example, the State reported in Reference 11 that in 1991 Subase Bangor's quarterly ambient gamma radiation level ranged from 0.12 to 0.17 mrem/day (equals 5.0 to 7.1 μ R/hr, or 11.0 to 15.5 mrem/quarter). For the same period, Table 6-14 reports average quarterly perimeter TLD readings between 15.0 and 16.0 mrem/quarter.

Prior to the start of field activities at each remedial investigation site at SUBASE Bangor, URS Consultants performed a radiation survey with a Geiger meter. Reference 12, dated 22 March 1993, reports that

"All radiation surveys [performed by URS Consultants at SUBASE Bangor] indicated no readings above background. Background was established prior to entering the site, usually at the field trailer located by public works."

6.4 Shoreline Monitoring Records

Puget Sound Naval Shipyard has conducted gamma radiation surveys of selected shore areas uncovered at low tide at Subase Bangor since the fourth quarter of 1973. The purpose of this monitoring is to determine if any radioactivity has washed ashore. These surveys are conducted during the second and fourth quarters of the year. Areas are selected based on the likelihood of suspended radioactivity being deposited by tidal currents upstream and downstream of nuclear ship berthing areas. Two or more background readings are taken at least thirty feet from the high water line at each survey location.

Table 6-7 summarizes the results of these surveys. The surveys were performed with a PRM-5N/SPA-3 gamma scintillation survey meter with a 2-inch by 2-inch sodium iodide detector. This instrument is calibrated to permit distinguishing between natural and non-naturally occurring radioactivity; it is not calibrated for the direct conversion of count rate data to natural background radiation dose rates.

Table 6-7
Shoreline Radiation Monitoring
Subase Bangor

Year	Average Background Count Rate kcpm	Range Shoreline Count Rate kcpm
1996	2.5	1.5 - 4.3
1995	2.7	1.4 - 4.8
1994	2.8	1.7 - 4.5
1993	3.0	1.9 - 4.5
1992	3.0	2.2 - 4.0
1991	2.8	1.8 - 4.0
1990	2.7	1.8 - 3.8
1989	2.7	1.9 - 6.0
1988	2.7	1.9 - 5.4
1987	3.1	2.4 - 5.5
1986	2.7	1.3 - 5.0
1985	2.7	1.5 - 4.0
1984	2.6	2.0 - 4.8
1983	2.5	1.7 - 5.0
1982	2.6	1.8 - 5.3
1981	2.6	1.8 - 5.3
1980	2.9	2.2 - 5.6
1979	3.8	2.5 - 6.5
1978	3.4	2.0 - 6.0
1977	3.0	2.3 - 5.5
1976	3.7	3.0 - 6.7
1975	3.0	2.7 - 6.0
1974	3.9	2.8 - 4.5
4th Quarter 1973	3.2	2.0 - 6.0

From fourth quarter 1973 through fourth quarter 1979, the shorelines near the Marginal Wharf and the Small Craft Pier (K/B Dock) were surveyed (Figure 6-1). Starting the first quarter of 1980, the shoreline survey was enlarged to include areas near the Magnetic Silencing Facility and the Explosive Handling Wharf. Also, the shoreline survey area along Marginal Wharf was extended to include the Delta Pier; see Figures 6-2 and 6-3. These areas are located within Subase and are thus readily accessible for monitoring.

The data of Table 6-7 show that since 1973 there has been no measurable increase in radioactivity along monitored shorelines.

6.5 Drydock Sampling Records

Drydocks routinely used by nuclear-powered ships are surveyed annually due to the potential to release radioactivity into the drainage and pumping systems. The results of drydock drain sampling are listed in Table 6-10.

Annual radiation surveys are also performed in drydocks when they are empty using a portable gamma survey instrument. The gamma radiation measurements are taken in a predetermined grid pattern covering the entire drydock floor. These surveys consistently find radiation levels indistinguishable from natural background.

The results show that G-RAM activities have had no measurable effect on normal background radiation levels.

Table 6-8
Drydock Drain Sediment Samples

Year	Number of Samples	Average Gross Gamma (0.1 - 2.1 MeV) pCi/g
1996	NA	NA
1995	NA	NA
1994	3	1.9 (1.3 Avg. MDA)
1993	2	3.9 (2.3 Avg. MDA)
1992	NA	NA
1991	NA	NA
1990	7	3.8 (1.8 Avg. MDA)

Notes: a. NA - not available.
b. MDA - Minimum Detectable Activity.

6.6 Routine Radiological Surveys

To ensure proper posting of radiation areas, gamma surveys are performed weekly in occupied radiological areas, including on piers and in the drydock alongside nuclear ships. Monthly surveys are performed on any potentially contaminated ducts, piping, or hoses in use. Surveys are performed quarterly in locked, unoccupied areas.

To verify no environmental release of contamination, surveys for loose surface contamination are conducted either each shift, daily, or weekly, depending on the work site and potential for release.

6.7 Independent Environmental Monitoring

As part of the field research conducted in July and August of 1981 to prepare the Initial Assessment Study (Reference 1), the Navy Assessment and Control of Installation Pollutants (NACIP) team performed radiation surveys in Buildings 7000 and 7721:

- The Strategic Weapons Facility, Pacific at Subase Bangor operates an electronic calibration laboratory in Building 7000, the Technical Services Building. The NACIP team performed a general area radiation survey of the calibration laboratory using a PRM-5N portable gamma scintillation survey. No readings above background were found. The survey was accomplished to identify electron tubes containing radioactive material and luminous radioactive materials; none were found.
- Based on interviews with Subase Bangor personnel, the NACIP team suspected that historical operations within Building 7721 may have involved G-RAM. In 1981 Building 7721 was controlled by Naval Undersea Warfare Engineering Station (NUWES), Keyport. The NACIP team performed a general area radiation survey in and around Building 7721 using a PRM-5N portable gamma scintillation survey; no readings were above background.

7.0 Residual Radioactivity

Based on environmental radioactivity data collected, analyzed, and reported by the Naval Ordnance Systems Command Environmental Health Center in 1969, the State of Washington since 1970, Puget Sound Naval Shipyard since 1973, the Navy Assessment and Control of Installation Pollutants team in 1981, the U.S. EPA in 1987, and URS Consultants in 1993, there is no significant amount of G-RAM radioactivity in Subase Bangor's environment.

NRMP-controlled G-RAM has not been disposed of at Subase Bangor. However, non-regulated G-RAM may have been unintentionally disposed of in the trash on Subase Bangor. The most likely indicator of such disposal would be radium-226. No evidence of such disposal has been identified.

Luminescent dials, gauges, switches and markers containing radium-226 were in common use in the Navy as well as in civilian industrial applications. Radium-226 has a long half-life, is a relatively high-energy-emitting radionuclide, and has historically not been regulated. It was typically the radioactive component in radioluminescent material generally available many years ago. However, site surveys conducted by the Navy and independent organizations have detected no increase in radium-226 or other naturally-occurring radionuclides, and no increases in natural background radiation levels.

In recent years, materials containing radium-226 are only occasionally detected by the Navy. The one Subase Bangor area where radium-226 contamination is known to have existed (Gauge Calibration Laboratory in 1984, see Section 5) was decontaminated to background levels.

Due to the wide-spread use of consumer products with radioactive sources, nearly every facility, structure, and operational area in Subase Bangor is likely to have contained minor exempt quantities of radioactive materials. Most such devices, such as smoke detectors and watches, contain either highly purified naturally-occurring radioactivity or very small amounts of radioactive material of low energy and/or short half-life. Such consumer products are not considered to be a source of G-RAM concern, and do not of themselves cause facilities (e.g., housing) to be classified as G-RAM areas in need of eventual release surveys in the event they are to be decommissioned.

8.0 Assessment of Environmental Impact

Reference 13, "Guidance for Performing Preliminary Assessments under CERCLA," lists four pathways of possible environmental transport, each evaluated by three elements. These pathways include ground water, surface water, soil exposure, and air. The elements are the likelihood of release (including the likelihood of a substance migrating through a specific pathway), the waste characteristics, and the targets.

The following sections evaluate the data and information presented in this report within the framework of Reference 13.

8.1 Ground Water Pathway

The ground water pathway considers potential exposure threats to drinking water supplies via migration to and within aquifers. It may also impact surface water and areas where ground water discharges.

That no radioactivity to infiltrate the aquifers exists above background levels is established in evaluating the soil exposure pathway in Section 8.3.

As discussed in Section 3.3.3.3, there are four aquifers underlying Subase Bangor: the Perched Aquifer, Semi-Perched Aquifer, Sea Level Aquifer, and Deep Aquifer. Contaminants, if present, could enter the Perched Aquifer through direct recharge from precipitation, and possibly the lower aquifers via leakage through overlying layers; however, there is no indication of aquifer interconnections. The gradient of the upper aquifer is very flat (less than 6 inches in one-half mile). At Floral Point, and by inference for the whole near shoreline area, the Perched Aquifer flows parallel to topography outward into Hood Canal. No drinking water is obtained from Hood Canal.

8.1.1 Release Mechanisms Affecting Ground Water

Radioactivity being released to ground water is the least likely mechanism. This could conceivably occur as a result of a release to the soil, atmosphere, or surface water. The radioactivity, which is primarily in an insoluble particulate form, would have to infiltrate through the soil to the ground water. Due to the slope of the land (See Figures 3-6 and 3-10), if a liquid release of radioactivity did occur in the industrial area it would most likely remain as surface water and migrate directly to Hood Canal; not to the aquifer.

8.1.2 Ground Water Targets

Primary targets are defined as populations served by drinking water wells that are suspected to have been exposed to a hazardous substance. There has been no suspected NNPP radioactivity release from the site to ground water; thus, no primary targets are identified.

Secondary targets include populations served by all drinking water wells within four miles of the site that are not suspected to have been exposed to a hazardous substance. Approximately 12,000 people reside within four miles of Delta Pier. All on-base residents and most off-base residents within four miles of Delta Pier obtain their drinking water from wells.

There are no Wellhead Protection Areas within the region. Since ground water within the four mile zone has uses other than drinking water, it would be considered a resource.

8.1.3 Ground Water Pathway Assessment

There has been no identifiable release of radioactivity which could threaten the ground water in the vicinity of Subase Bangor and no mechanism by which a potential contaminant could be transported to ground water users. Since ground water flow is into the harbor, harbor monitoring would detect any accumulation of environmental radioactivity from the ground water pathway; such monitoring has found no evidence of environmental radioactivity release via ground water.

8.2 Surface Water Pathway

The surface water pathway considers potential exposure threats to drinking water supplies, to human food chain organisms, and to sensitive environments.

Hood Canal is a salt water estuary; it is not used for drinking water. The other bodies of surface water associated with Subase Bangor (Hunter's Marsh, Wilkes Marsh, Devil's Hole, and Cattail Lake) are small lakes and marches which do not supply drinking water.

Analytical data collected by the shipyard consisting of harbor water, biota, and sediment samples, along with data reported in 1987 by the Environmental Protection Agency, have not detected any non-naturally-occurring radioactive material in any water or marine biota since sampling was begun. Naturally-occurring radioactivity (including the uranium series of which Ra-226 is a component) is within the range of normal background levels.

There are no primary sensitive environments within the 15-mile tidal influence zones of concern. Secondary sensitive environments consist of wetlands along the shorelines. Wetlands frontage exceeds 20 miles.

8.2.1 Release Mechanisms Affecting Surface Waters

Air release mechanisms can disperse radioactivity to local surface waters, but the potential effect of low level discharges via the air pathway is very small. Of greater potential concern would be direct liquid and solid material discharges to surface water. Leaks or ruptures from G-RAM sources on a pier could spill their contents into the harbor. Additionally, spillage of radioactive liquids to the Subase Bangor storm drain system could ultimately reach the harbor. Leakage to ground water could also pass to surface water, should it ever occur. Generally speaking, however, potential sources of G-RAM are small and isolated, and spills would be readily contained.

8.2.2 Surface Water Targets

Surface water targets are subdivided into drinking water, human food chain, and environmental.

Figure 3-12, Surface Waters With Domestic Water Rights, lists 62 named surface waters with domestic water rights within the 15 mile target distance. In most cases the listed surface waters are used by only a few (one to three) households. At an average of two households per named surface water and four people per household, about 500 people reside in houses with surface water domestic water rights.

Sport and commercial fishing occur within the 15 mile target distance limit. Economically important fish and shellfish resources are discussed in Section 3.3.3.4. The most commercially important migratory fish species in Hood Canal is chum salmon, followed by chinook, coho, and pink salmon. Commercially important resident ground fish species include English sole, rock sole, Pacific cod, surf perch, and dogfish. Intertidal and subtidal shellfish populations in Hood Canal also support significant commercial and recreational fisheries. Predominant species are oysters, geoducks, Dungeness crab, shrimp, horse clams, butter clams, and Manila littleneck clams.

The estimated annual production of 10,000 to 100,000 pounds per year for the shellfish fisheries in the Kitsap basin is based on harvest/production values prior to 1982, when some waters were closed. At the time of peak production, all species of salmon produced in Kitsap basin ranged from 200,200 to 462,100 pounds per year for the years 1966 to 1971. The smelt and herring annual harvests are estimated to be greater than 1,000 to 10,000 pounds per year.

Table 8-1 lists all surface water bodies within the 15 mile tidal influence zone.

Table 8-1
Water Bodies Within The 15 Mile Tidal Influence Zone

East Shore Hood Canal		
Port Gamble Big Valley Creek Anderson Creek Big Beef Harbor	Big Beef Creek Little Beef Creek Seabeck Bay Seabeck Creek	Stavis Bay Stavis Creek Frenchman's Cove Boyce Creek
West Shore of Hood Canal		
Bywater Bay Squamish Harbor Thorndike Bay Fisherman Harbor	Dosewallips River Pleasant Harbor Duckabush River	McDaniel Cove McDonald Creek Fulton Creek
Dabob Bay		
Tarboo Bay Tarboo Creek Quilcene Bay Donovan Creek	Indian George Creek Quilcene River Jackson Cove Spencer Creek	Marple Creek Jackson Creek Turner Creek

There are no critical habitats as defined in 50 CFR 424.02 within the tidal influence zone.

A variety of ecosystems exist at Subase Bangor, including mixed coniferous forests, recovering logged areas and grasslands, freshwater wetlands, freshwater lakes and ponds, and marine intertidal and subtidal zones. The diversity of ecosystems provides important habitats for a variety of species, some uncommon in western Washington. Although there are no known federal endangered or threatened floral or faunal species inhabiting Subase Bangor at this time, the bald eagle has been sighted in the area.

Sensitive environments are defined as terrestrial or aquatic resources, fragile natural settings, or other areas with unique or highly-valued environmental or cultural features. Typically, areas that fall within the definition of "sensitive environment" are established and/or protected by State or Federal law. Examples include National Parks, National Monuments, habitats of threatened or endangered species, wildlife refuges, and wetlands. As discussed in Section 3.3.3.6, Subase Bangor contains three wetlands: Devil's Hole, Cattail Lake, and Hunter's Marsh.

No national parks or monuments, national seashore or lake shore recreational areas, national preserves, federal wilderness areas, federal Scenic or Wild Rivers, wildlife management areas, or state designated natural areas have been identified within the tidal influence zone.

State parks within 15 miles upstream or downstream of Subase Bangor include Kitsap Memorial State Park, Scenic Beach State Park, Pleasant Harbor State Park, and Dosewallips State Park.

Wetlands within the 15-mile radius of Subase Bangor exceed 20 miles, the maximum assigned value under PA or HRS scoring. However, the dynamics of transport of any potentially released G-RAM in the forms used, if any were present, make it unlikely for any radioactivity to reach even the closest wetland area. None of the inadvertent releases described in Section 5.1.3 appear to be within a completed pathway for surface water.

8.2.3 Surface Water Pathway Assessment

Previous sections of this report have established that no drinking water intakes from either surface or ground water could be affected by any potential release via discharge, precipitation run-off, or percolation. Surface drainage (precipitation run-off and run-off of accidental discharges, if any) in the industrial area is always toward Hood Canal. The nearest drinking water intake from surface waters is Dog Fish Creek, about two and one-half miles east of Delta Pier. The creek drains into Liberty Bay. If percolation did occur at the base it would be to Hood Canal.

The Navy concludes that radioactivity in surface waters will not damage sensitive environments as described by Reference 13. As discussed above and in Section 6, no water, marine biota, or sediment samples have shown levels of non-naturally-occurring radioactivity, nor have any shorelines within the littoral zone accumulated any radioactivity above normal background levels. This evidence supports the conclusion that there has been no environmentally detrimental release of G-RAM to surface waters surrounding Subase Bangor.

8.3 Soil Exposure Pathway

The soil exposure pathway considers potential exposure threats to people on or near the site who may come into contact with a hazardous substance via dermal exposure, soil ingestion, or plant uptake into the human food chain.

Subase Bangor is actively engaged in G-RAM work. As such, there are radiological facilities containing radioactivity associated with this work. These facilities and the radiological controls applied to prevent contamination of workers and the environment are discussed in other sections of this report.

For areas and facilities other than those discussed above, this report concludes that there is no likelihood for exposure to humans or to the environment. This conclusion is based on the following:

- Perimeter radiation levels have consistently been comparable to background radiation levels as measured by Puget Sound Naval Shipyard (PSNS) and the Environmental Protection Agency (EPA).
- Shoreline surveys conducted by PSNS and the EPA found no radionuclides along the shore attributable to Navy activities.
- Results of drydock surveys and samples are consistent with background radiation levels.
- There have been no reported releases of G-RAM radioactivity onto soil at Subase Bangor.
- There have been no reported airborne releases of G-RAM radioactivity at Subase Bangor which could have transported radioactivity onto soil.
- There has been no solid G-RAM radioactive waste disposal on or near Subase Bangor property, as documented by regulatory prohibition, review of historical disposal records, and review of measured radiation levels.

Since the above evidence would result in a "no likelihood of exposure" finding, the other elements of the soil exposure pathway do not need to be evaluated.

8.3.1 Release Mechanisms Affecting Soil

The release mechanisms discussed in the air pathway section could deposit radioactivity in the soil of affected areas. Radioactive liquid spills to the soil would be much more localized and concentrated than soil contamination resulting from low level airborne radioactivity releases. Liquid spills with the highest potential for reaching the soil are related to activities performed outside of radiological work areas such as the movement of small liquid containers such as plastic bottles. Spills of radioactive liquids inside work facilities are expected to be contained within that facility but could reach the soil through cracks in building materials or by leaching through porous building materials such as concrete. Also, in the event of a fire in a radioactive material storage area, the large volumes of water needed to control the fire could result in the transport of radioactive materials into the soil.

8.3.2 Soil Exposure Targets

There are no residences, schools, or daycare facilities within 200 feet of any potential source of G-RAM.

There are about 8,000 employees working on the base, including Subase and all tenant commands.

There are no terrestrial sensitive environments that have been identified within a four-mile radius of Subase Bangor.

There is no land resource use for commercial agriculture or commercial livestock production or grazing within a four-mile radius of Subase Bangor. The base sells its marketable timber.

8.3.3 Soil Exposure Pathway Assessment

The results of environmental monitoring, as discussed in Section 6, and the factors described in this section support the conclusion that there has been no adverse impact on human health or the environment due to the soil exposure pathway.

8.4 Air Pathway

The air pathway considers potential exposure threats to people and to sensitive environments via migration through the air.

As discussed in Section 5, no G-RAM work requiring monitored and/or filtered exhaust ventilation is performed at Subase Bangor. Other potential sources of airborne radioactivity, such as from contaminated soil or spills of contaminated liquids, have been discussed in other sections of this report. Based on the absence of detectable soil contamination, and the immediate containment and recovery actions taken for spills, Puget Sound Naval Shipyard considers these potential sources of airborne radioactivity to be negligible.

The operation involving unsealed solid or liquid non-NRMP-controlled G-RAM having the greatest potential for airborne release is grinding on thoriated welding rods. As discussed in Section 5.1.2, all such work is performed under controlled conditions (e.g., wet belt machine, clean-up of dust and chips as they are generated) which minimize the potential for airborne release of this material. This material is exempt from licensing requirements per 10 CFR 40.

8.4.1 Release Mechanisms Affecting the Air

Consideration of atmospheric releases is necessary since such releases would potentially allow radioactivity to contact the soil and surface water. Some mechanisms that could cause an atmospheric release of G-RAM include: fire in an area where G-RAM is used or stored; or loss of containment for items being stored or handled, including tears in packaging material, leaks from liquid storage containers, and breaches of sealed sources.

8.4.2 Air Targets

Target populations under the air pathway consist of people who reside, work, or go to school within the 4-mile target distance limit around the site. Preliminary Assessment air pathway targets also include sensitive environments and resources.

Targets are evaluated on the basis of their distance from the site. Those persons closest to the site are most likely to be affected and are evaluated as primary targets. The nearest individual would be an on-site worker.

Like the other migration pathways, a release must be suspected in order to score primary targets for the air pathway. Releases to the air pathway, however, are fundamentally different from releases to the other migration pathways. Depending on the wind, air releases may disperse in any direction. Therefore, when a release is suspected, all populations and sensitive environments out to and including the 1/4 mile distance category are evaluated and scored as primary targets. Because air releases are quickly diluted in the atmosphere, targets beyond the 1/4 mile distance are evaluated as secondary targets.

As with other migration pathways when a release is not suspected, the residential, student, and worker population within the entire 4-mile target distance limit is evaluated as the secondary target population. The population distribution for the secondary target population is given in Sections 3 and 8.3.2.

As discussed in Section 3.3.3.4, Subase Bangor contains three major wetlands: Devil's Hole, Cattail Lake, and Hunter's Marsh. Except for wetlands, there are no sensitive environments within 1/2 mile of Subase Bangor.

The resources factor accounts for land uses around the site that may be impacted by release to the air:

- Commercial agriculture
- Commercial silviculture (e.g., tree farming, timber production, logging)
- Major or designated recreation area (e.g., municipal swimming pool, campground, park)

There are no commercial agriculture or silviculture land resources within a 1/2 mile of Subase Bangor. Subase Bangor has a managed logging program and recreation areas.

8.4.3 Air Pathway Assessment

Searches of historical records have revealed no occurrences or practices which could have released significant quantities of G-RAM into the air. The record of environmental monitoring, as discussed in Section 6, does not indicate the presence of any airborne radioactivity other than that which is naturally-occurring (and which is within normal background ranges).

The reports of inadvertent releases in Section 5 do not include any occurrences with a potential for significant airborne radioactivity releases.

These factors support the conclusion that the potential exposure threat to targets via migration of G-RAM through the air at the shipyard is insignificant.



9.0 Conclusions

Evaluation of the information and analytical data presented in this HRA leads to the conclusion that past and current activities at Subase Bangor associated with G-RAM work have had no adverse impact on the human population or ecosystem of the region.

There is no known residual G-RAM radioactivity in the environment which could be considered for remediation.

Subase Bangor will continue to follow Navy radiological control practices and PSNS will continue to perform environmental monitoring as discussed in this HRA. Within the framework of the CERCLA process, no further action is warranted regarding radioactivity associated with general radioactive material at Subase Bangor.

GLOSSARY (continued)

- HRA:** Historical Radiological Assessment. A compilation of site historical radiological data derived from the site environmental monitoring program and other records. This document is intended to be an integral part of a FFA.
- HRS:** Hazard Ranking System. EPA's principal mechanism for placing sites on the NPL.
- IAS:** Initial Assessment Study. A study done under the Navy's Installation Restoration program. This study parallels the PA.
- kcpm:** Thousand counts per minute.
- micro:** Abbreviated μ . A prefix denoting a one-millionth part (10^{-6}).
- milli:** Abbreviated m. A prefix denoting a one-thousandth part (10^{-3}).
- NAVSEA:** Naval Sea Systems Command. The Navy command responsible for radiological controls associated with industrial radiography and radiation detection instrument calibration.
- NEHC:** Navy Environmental Health Center. NEHC provides technical support to the NRSC for radiological controls associated with NRMP-related activities under BUMED cognizance.
- NNPP:** Naval Nuclear Propulsion Program. A joint Navy/Department of Energy program to design, build, operate, maintain, and oversee operation of Naval nuclear-powered ships and associated support facilities.
- No Suspected Release:** A professional judgment based on site and pathway conditions indicating that a hazardous substance is not likely to have been released to the environment.
- NPL:** National Priorities List. Under the Superfund program, the list of sites of releases and potential releases of hazardous substances, pollutants, and contaminants that appear to pose the greatest threat to public health, welfare, and the environment.
- NRMP:** Navy Radioactive Material Permit. Site-specific or broad scope Navy license for the use of specified radioactive material under specified conditions. These permits are issued by the Navy Radiation Safety Committee under the authority of the Master Materials License granted to the Navy by the Nuclear Regulatory Commission.

GLOSSARY (continued)

- NRSC:** Navy Radiation Safety Committee. Navy organization providing administrative control of all Nuclear Regulatory Commission-licensable radioactive material used in the Navy and Marine Corps.
- PA:** Preliminary Assessment. Initial stage of site assessment under CERCLA; designed to distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation.
- pico:** Abbreviated p. A prefix denoting a one-trillionth part (10^{-12}).
- PSNS:** Puget Sound Naval Shipyard
- R:** Roentgen. A unit of exposure. For cobalt-60 radiation, a roentgen and a rem are considered to be equivalent.
- RADCAL:** Radiation Detection, Instrumentation, and Calibration Laboratory.
- RASO:** Radiological Affairs Support Office. RASO provides technical support to the NRSC for radiological controls associated with NRMP-related activities under NAVSEA cognizance.
- rem:** Roentgen Equivalent Man. A measure of radiation dose.
- SARA:** Superfund Amendments and Reauthorization Act of 1986. Legislation which extended the Federal Superfund Program and mandated revision to the HRS.
- Subase:** Naval Submarine Base Bangor.
- Surface Water:** A naturally-occurring, perennial water body; also, some artificially-made and/or intermittently-flowing water bodies.
- Suspected Release:** A professional judgment based on site and pathway conditions indicating that a hazardous substance is likely to have been released to the environment.
- Target:** A physical or environmental receptor that is within the target distance limit for a particular pathway. Targets may include wells and surface water intakes supplying drinking water, fisheries, sensitive environments, and resources.

GLOSSARY (continued)

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GLOSSARY (continued)

Target Distance Limit: The maximum distance over which targets are evaluated. The target distance limit varies by pathway; ground water and air pathways -- a 4-mile radius around the site; surface water pathway -- 15 miles downstream from the probable point of entry to surface water; soil exposure pathway -- 200 feet (for the resident population threat) and 1 mile (for the nearby population threat) from areas of known or suspected contamination.

Target population: The human population associated with the site and/or its targets. Target populations consist of those people who use target wells or surface water intakes supplying drinking water, consume food chain species taken from target fisheries, or are regularly present on the site or within target distance limits.

Terrestrial Sensitive Environment: A terrestrial resource, fragile natural setting, or other area with unique or highly-valued environmental or cultural features.

TLD: Thermoluminescent dosimeter. A device for measuring gamma radiation exposure.

Wetland: A type of sensitive environment characterized as an area that is sufficiently inundated or saturated by surface or ground water to support vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Worker: Under the soil exposure pathway, a person who is employed on a full or part-time basis on the property on which the site is located. Under all other pathways, a person whose place of full- or part-time employment is within the target distance limit.

< : Less than.

> : Greater than.

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SUBMARINE BASE BANGOR
HISTORICAL RADIOLOGICAL ASSESSMENT
VOLUME II
GENERAL RADIOACTIVE MATERIAL

CROSS-REFERENCE CHART FOR VOLUME II REFERENCES

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Note: (a) Reference 12 is provided under separate cover.